The world's most comprehensive encyclopedia of the military weapons of the 20th century

WAR MACHINE

An ORBIS Publication

90p 93

IR £1.15 Aus $2.15 NZ $2.65 SA R2.45 Sing $4.50

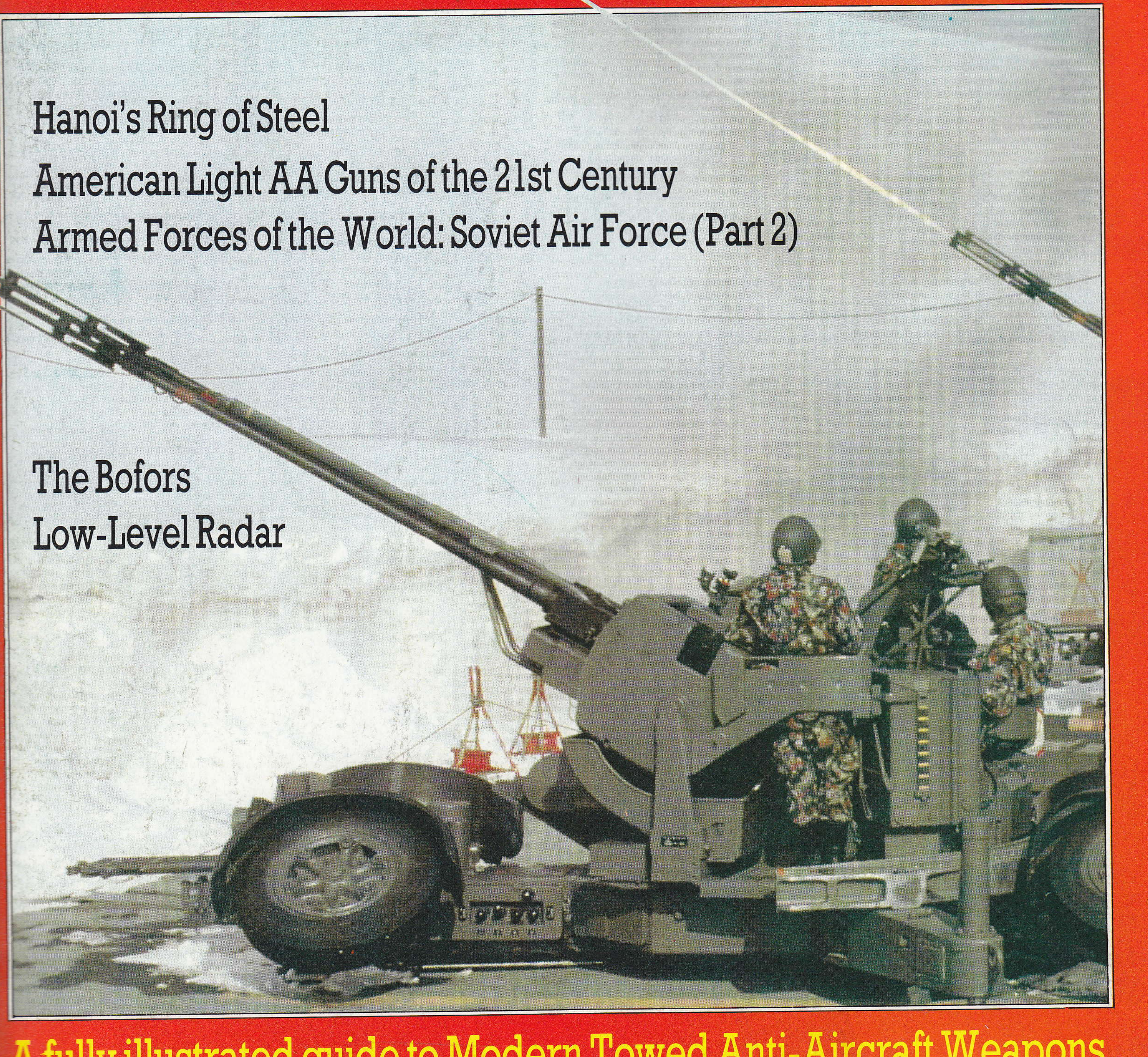
Hanoi's Ring of Steel

American Light AA Guns of the 21st Century

Armed Forces of the World: Soviet Air Force (Part 2)

The Bofors

Low-Level Radar



A fully illustrated guide to Modern Towed Anti-Aircraft Weapons

WAR MACHINE

Volume 8 **Issue 93**

Published by
Orbis Publishing Ltd
© Aerospace Publishing Ltd 1985

Editorial Offices
War Machine
Aerospace Publishing Ltd
179 Dalling Road
London W6 0ES

Managing Editor: Stan Morse
Editorial: Trisha Palmer
Chris Bishop
Chris Chant
Ian Drury

Design: Rod Teasdale
Colour Origination: Imago Publishing Ltd, Thame, Oxon

Typesetting: SX Composing Ltd

Film work: Precise Litho Ltd

Artists:
Ray Hutchins
Richard Hook

13856

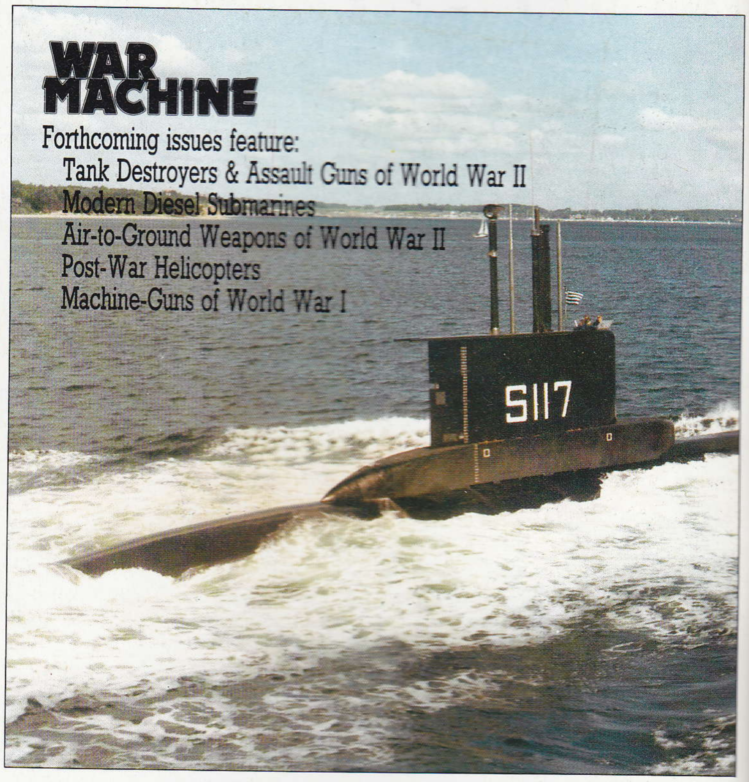
Printed in Great Britain
by The Artisan Press Ltd

Subscription Manager: Christine Allen
0488 72666

Consultant Editor: Major General Sir Jeremy Moore KCB OBE MC, Commander of British Land Forces during the Falklands campaign.

Distribution and marketing offices:
Orbis Publishing Ltd
Orbis House
20-22 Bedfordbury
London WC2N 4BT
Telephone: 01-379 6711

Circulation Director: David Breed
Marketing Director: Michael Joyce



WAR MACHINE

Forthcoming issues feature:
Tank Destroyers & Assault Guns of World War II
Modern Diesel Submarines
Air-to-Ground Weapons of World War II
Post-War Helicopters
Machine-Guns of World War I

Picture acknowledgements

Cover photograph: Oerlikon. **1841:** Oerlikon/Rheinmetall. **1842:** R.F./R.F. **1843:** Breda/R.F. **1844:** R.F. **1845:** R.F./R.F. **1846:** R.F./R.F./R.F. **1847:** US Army/R.F. **1848:** R.F./R.F. **1849:** General Electric. **1851:** General Electric via R.F. **1852:** General Electric. **1853:** Rheinmetall/R.F. **1855:** Vietnamese Army. **1856:** Vietnamese Army. **1857:** R.F./R.F. **1858:** R.F. **1859:** Bofors/Bofors. **1860:** Bofors/R.F./R.F./R.F. **(iii):** US Navy.

HOW TO OBTAIN ISSUES AND BINDERS FOR WAR MACHINE

Issues can be obtained by placing an order with your newsagent or direct from our Subscription Department. If you have difficulty obtaining any back issues from your newsagent, please write to us stating the issue(s) required and enclosing a cheque for the cover price of the issue(s).

AUSTRALIA please write to: Gordon and Gotch (Aus) Ltd, 114 William Street, PO Box 767G, Melbourne, Victoria 3001. MALTA, NEW ZEALAND, SINGAPORE & SOUTH AFRICA: Back numbers are available at cover price from your newsagent. In case of difficulty, write to the address given for binders.

UK/EIRE
PRICE: 90p/IR£1.15
SUBSCRIPTION:
6 Months: £26.00
1 Year: £52.00
BINDER: Please send £3.95 per binder, or take advantage of our special offer in early issues.

EUROPE
PRICE: 90p
SUBSCRIPTION:
6 Months air: £44.72
surface: £36.14
1 Year air: £89.44
surface: £72.28
BINDER: (inc. Postage)
air: £5.50
surface: £5.00

MALTA
Obtain BINDERS from
your newsagent or
Miller (Malta) Ltd,
MA Vassalli Street,
Valetta, Malta
Price: £3.95

MIDDLE EAST
PRICE: 90p
SUBSCRIPTION:
6 Months air: £50.18
surface: £36.14
1 Year air: £100.36
surface: £72.28
BINDER: (inc. Postage)
air: £8.25
surface: £5.50

AMERICAS/ASIA/AFRICA
PRICE: US$1.95/90p
SUBSCRIPTION:
6 Months air: £59.24
surface: £36.14
1 Year air: £119.08
surface: £72.28
BINDER: (inc. Postage)
air: £9.50
surface: £5.50

SOUTH AFRICA
PRICE: SA R2.45
Obtain BINDERS from
any branch of Central
News Agency or
Intermag, PO Box
57394, Springfield 2137

SINGAPORE
PRICE: Sing$4.50
Obtain BINDERS from
MPH Distributors
601 Sims Drive
03-07-21
Singapore 1438

AUSTRALASIA/FAR EAST
PRICE: 90p
SUBSCRIPTION:
6 Months air: £64.22
surface: £36.14
1 Year air: £128.44
surface: £72.28

AUSTRALIA
PRICE: AUS $2.15
Obtain BINDERS from
First Post Pty Ltd,
23 Chandos Street
St Leonards,
NSW 2065

NEW ZEALAND
PRICE: NZ $2.65
Obtain BINDERS from
your newsagent or
Gordon & Gotch (NZ)
Ltd, PO Box 1595,
Wellington

ADDRESS FOR BINDERS AND BACK ISSUES
Orbis Publishing Limited
Orbis House
20-22 Bedfordbury
London
WC2N 4BT
Telephone: 01-379-5211

Cheques/Postal Orders should be made payable to Orbis Publishing Limited. Binder prices include postage and packing and prices are in sterling.

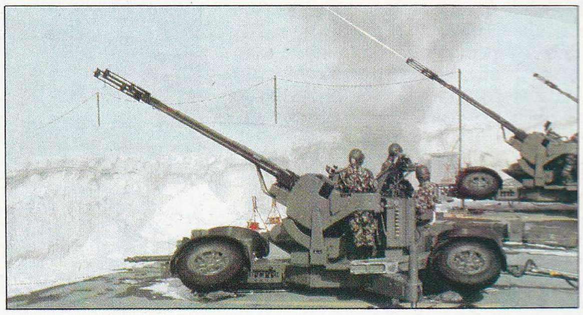
Back Issues are sold at the cover price, and we do not charge carriage in the UK.

NOTE
Binders and back issues are obtainable subject to availability of stocks. Whilst every attempt is made to keep the price of the issues and binders constant, the publishers reserve the right to increase the stated prices at any time when circumstances dictate. Binders depicted in this publication are those produced for the UK and Australian markets only. Binders and Issues may be subject to import duty and/or local taxes, which are not included in the above prices unless stated.

ADDRESS FOR SUBSCRIPTIONS
Orbis Publishing Limited
Hurst Farm
Baydon Road
Lambourne Woodlands
Newbury
Berks
RG16 7TW
Telephone: 0488-72666

All cheques/Postal Orders should be made payable to Orbis Publishing Limited. Postage and packaging is included in subscription rates, and prices are given in Sterling.

Modern Towed Anti-Aircraft Weapons



The Oerlikon 35-mm GDF system is used by over 20 countries. Recent operators include the RAF, which has just formed a unit to use the Oerlikons captured in the Falklands. Argentine Oerlikons shot down four Harriers and at least two of their own aircraft during the conflict.

Cheaper, easier to maintain and more flexible than their self-propelled counterparts, towed anti-aircraft guns nonetheless employ sophisticated tracking and fire control systems, making them a serious threat to ground attack aircraft.

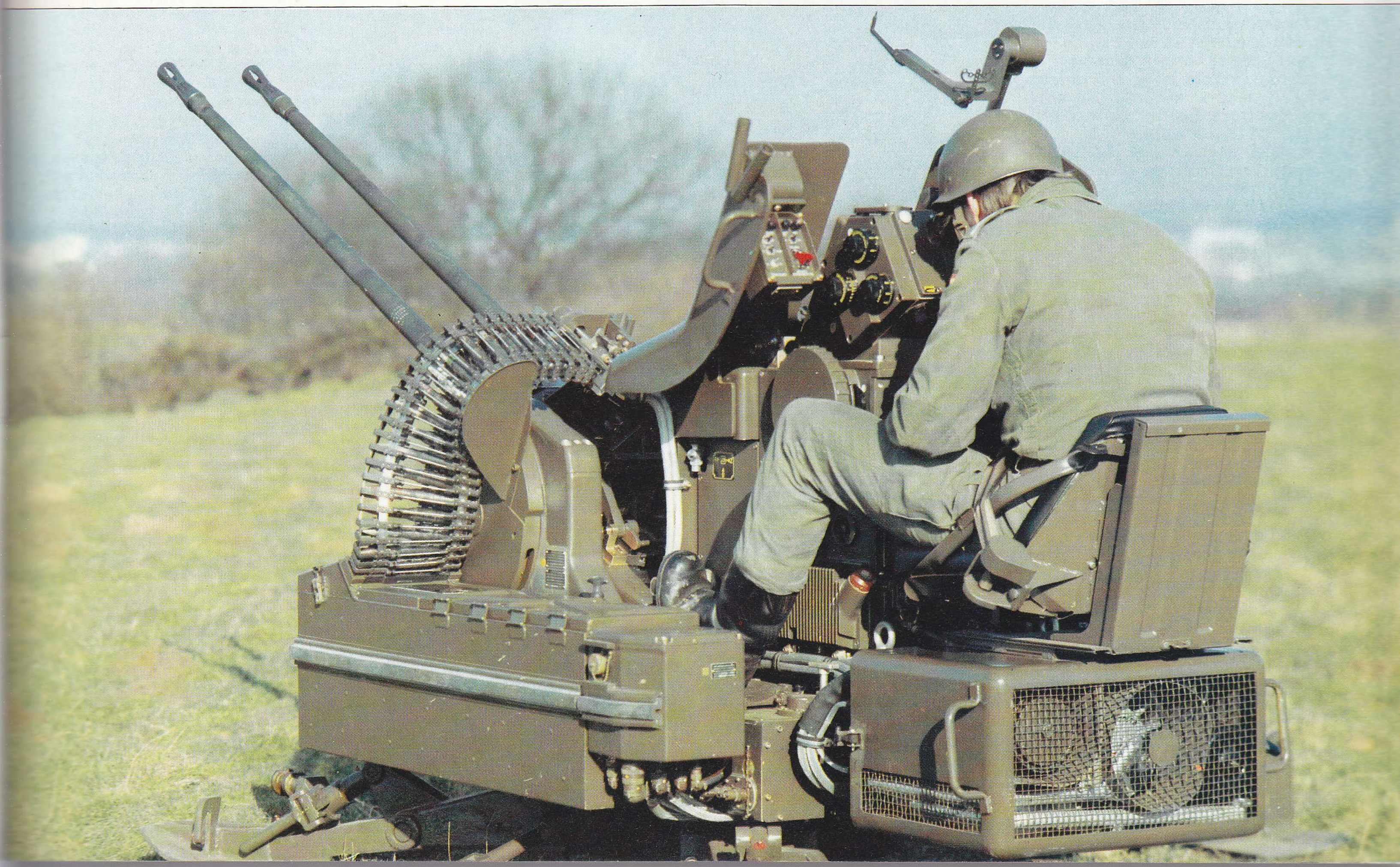
Since aircraft first appeared over the battlefield, anti-aircraft weapons have been developed and employed in an effort to stop them. During World War II a variety of anti-aircraft guns ranging in calibre from 12.7-mm machine-guns up to 120-mm guns were employed by the major powers in an effort to combat air attacks. By the end of the war bombers were flying higher and faster, and it was realized that anti-aircraft guns, even with proximity-fused ammunition and complex radar fire-control systems, were incapable of stopping them.

The major powers, namely the UK, USA and USSR, soon started to develop surface-to-air missiles such as the Bloodhound, Nike-Hercules and SA-2 'Guideline' which could successfully intercept aircraft flying very fast and very high. This forced the aircraft to adopt new tactics and fly very low to escape the surface-to-air missiles and radar systems.

Most countries today employ a mix of guns and missiles to defend their forward units. In the major powers these are normally self-propelled weapons such as the Soviet 23-mm ZSU-23-4 or the West German twin 35-mm Gepard. Many countries do, however, use towed anti-aircraft guns on a large scale as these are not only much cheaper than their self-propelled counterparts but are easier to maintain and operate. In most cases, moreover, they can be rapidly transported by aircraft or helicopter to where they are most needed. Towed anti-aircraft guns are also widely used to defend static areas such as supply dumps, airfields and command centres. In these cases they are often integrated into an overall air-defence system.

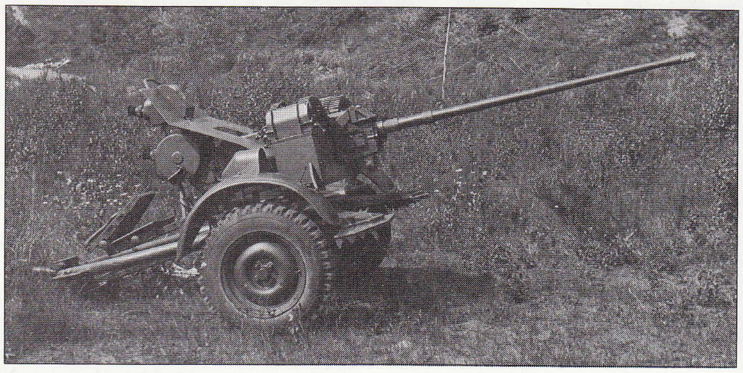
The Middle East campaigns of 1973, the Vietnam conflict and more recently the Falklands campaign have proved that the light anti-aircraft gun is a real complement to missiles: not only has it a quicker reaction time in many situations, but it is also highly effective in the ground-to-ground role.

The Rheinmetall 20-mm anti-aircraft gun is fitted with the Italian Galileo P56 computing sight. The gunner uses a joystick to elevate and traverse the guns and an analogue computer calculates the lead angles necessary to hit the target aircraft.

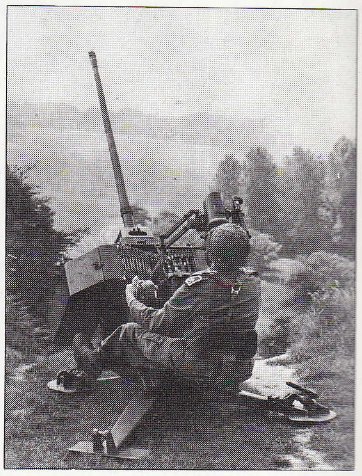


NORWAY

20-mm FK 20-2 light anti-aircraft gun



The 20-mm FK 20-2 anti-aircraft gun is a joint development between Norway and West Germany and uses the same 20-mm MK 20 Rh 202 cannon as the twin 20-mm Rheinmetall system used by the West German army and air force.



This 20-mm FK 20-2 anti-aircraft gun in the firing position clearly shows the two magazines, one each side of the barrel holding 75 rounds of ready-use ammunition. The gunner has a dual sight which enables him to track both aerial and ground targets easily.

The 20-mm **FK 20-2** light anti-aircraft gun mounting was developed to meet the rather special requirements of the Norwegian armed forces and certain units of the West German army. The Rheinmetall twin 20-mm light anti-aircraft gun is widely used by the West German army, but its weight of 2160 kg (4,762 lb) is too great to permit the type's use by airborne and mountain units. The FK 20-2 weighs only 620 kg (1,367 lb) in its travelling configuration and can be quickly disassembled to allow transport by pack animals.

Companies involved in the design and development of the FK 20-2 included A/S Kongsberg Vappenfabrikk of Norway, Rheinmetall of West Germany, Hispano-Suiza of Switzerland (since taken over by Oerlikon-Bührle) and Kern, the last responsible for the sight.

The FK 20-2 is fitted with the Rheinmetall 20-mm MK 20 Rh 202 cannon as installed in the twin 20-mm mount used by the West German army and air force. The gunner can fire either single shots or bursts, the cannon having a cyclic rate of fire of 1,000 rounds per minute. A total of 160 rounds of ready-use ammunition is provided; of these, 150 are normally anti-aircraft ammunition and the remaining 10 armour-piercing for the engagement of armoured vehicles. On each side of the cannon is a box of 75 rounds of ammunition (high explosive incendiary/HEI or high explosive incendiary-tracer/HEI-T), while above the cannon is a box of 10 rounds of armour-piercing discarding sabot-tracer (APDS-T). Traverse and elevation are manual via two hand wheels, which have the optical sight mounted between them. The latter has a magnification of ×1.5 for engaging aerial targets and ×5 for engaging ground targets. The sight has two eyepieces: the upper one is used when the gunner is seated while the lower one is used when the gunner is engaging ground targets from the much safer prone position. To the front of the gunner is a small shield, but in peace this is often removed to save weight.

The system is normally mounted on a two-wheeled carriage that can be towed by any light 4×4 cross-country vehicle, which also carries the three-man crew and a supply of ready-use ammunition.

In the firing position the weapon is supported on three outriggers, one at the rear and one on each side. The FK 20-2 is a clear-weather system only with no capability for radar control. Other anti-aircraft systems used by the Norwegian army include the American 12.7-mm (0.5-in) quadruple machine-gun, Bofors RBS-70 surface-to-air missile system and Bofors 40-mm L/60 and L/70 towed anti-aircraft guns.

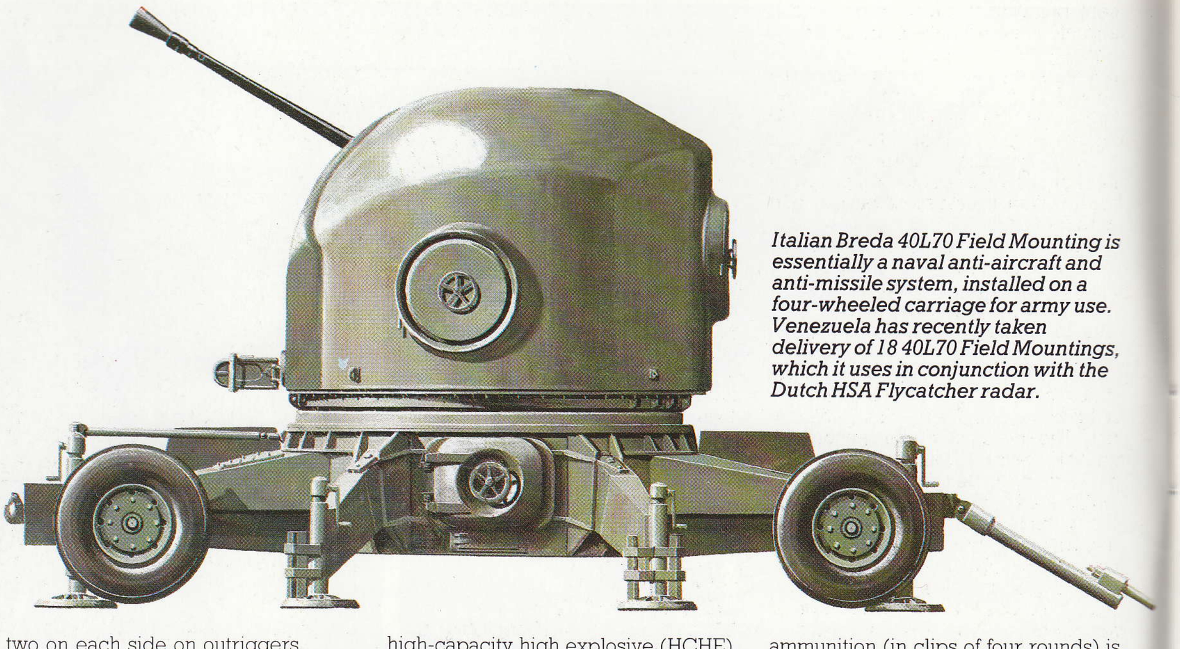
The 20-mm Rheinmetall MK 20 Rh 202 cannon is also used by the Norwegian army, installed in a one-man Swedish turret mounted on M113 armoured personnel carriers.

Specification

FK 20-2
Calibre: 20 mm (0.79 in)
Weights: travelling 620 kg (1,367 lb); firing 440 kg (970 lb)
Dimensions: length travelling 4.00 m (13 ft 1.5 in); width travelling 1.86 m (6 ft 1.2 in); height travelling 2.20 m (7 ft 2.6 in)
Elevation: +83°/−8°
Traverse: 360°
Ranges: maximum horizontal 6000 m (6,562 yards); maximum vertical 4500 m (14,764 ft); effective vertical 2000 m (6,562 ft)
Crew: 3 (1 on mount)

ITALY

Breda 40-mm 40L70 anti-aircraft gun



Italian Breda 40L70 Field Mounting is essentially a naval anti-aircraft and anti-missile system, installed on a four-wheeled carriage for army use. Venezuela has recently taken delivery of 18 40L70 Field Mountings, which it uses in conjunction with the Dutch HSA Flycatcher radar.

For many years the Breda company of Brescia has been involved in the design and production of a wide range of weapons for both naval and ground forces. One of its most important naval weapons is the Compact Twin 40-mm L/70 Type 70 Naval Mount, which is already in service with over 20 navies and used in conjunction with an Orion radar to provide a close-defence system against both aircraft and air- or sea-launched anti-ship missiles. The company realized that this weapon also had an army application for the defence of high-value targets such as airfields, command posts, oil installations and so on. The 40-mm **Breda 40L70** mount is now in service with Venezuela, which already has the original naval installation in service on board its six 'Lupo' class frigates. The 40L70 cannot be used alone as it has no fire-control system, but a wide range of fire-control systems is available from a number of manufacturers, a typical equipment being the Dutch Hollandse Signaalapparatean Flycatcher. When used in conjunction with the Flycatcher the complete system is known as the **Guardian**. A typical fire unit consists of two 40-mm 40L70s, one Flycatcher fire-control system, and generators.

The twin 40-mm 40L70 mount is essentially the standard naval turret installed on a four-wheeled carriage. In the firing position the system is supported on six jacks that are adjustable to suit the different ground conditions; one jack is located at each end of the carriage, and the other four are placed two on each side on outriggers.

Turret traverse and weapon elevation are electric at a maximum traverse speed of 90° per second. The mount has two 40-mm 70-calibre Bofors guns which have a cyclic rate of fire of 300 rounds per barrel per minute. Ammunition is identical to that used in the famous Bofors L/70 anti-aircraft gun and includes proximity-fused pre-fragmented high explosive (PFHE), high-capacity high explosive (HCHE), high explosive-tracer (HE-T), armour-piercing capped-tracer (APC-T) and target practice. To engage aerial targets such as helicopters, aircraft and missiles the PFHE round would be used as it produces over 2,400 fragments of which some 600 are tungsten pellets, which can penetrate 14 mm (0.55 in) of aluminium.

A total of 444 rounds of 40-mm ammunition (in clips of four rounds) is provided under the turret, and the empty cartridge cases are ejected outside the forward part of the turret. When firing the turret is unmanned, being controlled by the operator in the fire-control centre.

For many years Breda has been producing the Bofors 40-mm L/70 anti-aircraft gun under licence, including the towed system. To increase the rate of fire of the latter weapon Breda has designed an automatic feeding device which increases cyclic rate of fire from 240 to 300 rounds per minute, with a total of 144 rounds carried for ready use.

More recently Breda has developed to the prototype stage a twin 30-mm towed anti-aircraft gun which uses the West German 30-mm Mauser Model F gun, which has a cyclic rate of fire of 800 rounds per gun per minute. Each barrel has 250 rounds of ready-use ammunition. The system is fitted with the Italian Galileo P75D optronic fire-control system and a on-carriage power unit.

Specification

Breda 40-mm 40L70

Calibre: 40 mm (1.57 in)

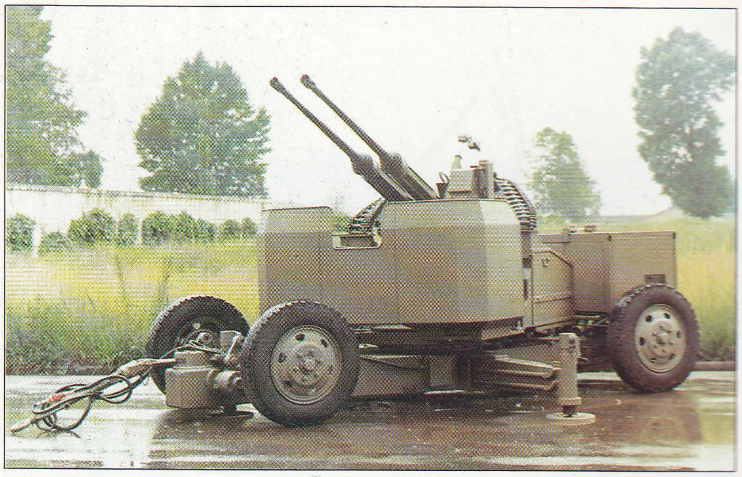
Weights: travelling without ammunition 9900 kg (21,826 lb); travelling with ammunition 10966 kg (24,176 lb)

Dimensions: length travelling 8.05 m (26 ft 4.9 in); width travelling 3.20 m (10 ft 6 in); height travelling 3.65 m (11 ft 11.7 in)

Elevation: +85°/–13°

Traverse: 360°

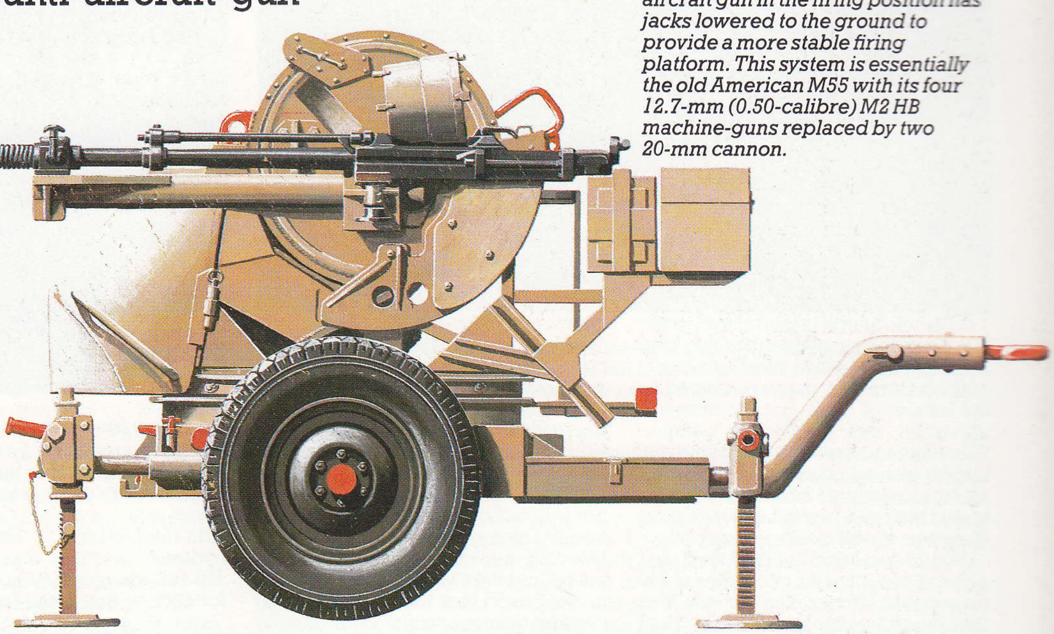
Ranges: maximum horizontal 12500 m (13,670 yards); maximum vertical 8700 m (28,543 ft); effective vertical 4000 m (13,123 ft)



The Breda 40-mm 40L70 Field Mounting has a total of 444 rounds of ammunition ready for immediate use. When the weapon is firing no crewmen are present as the guns are aimed and fired by remote control by the Flycatcher fire control system.

ISRAEL

20-mm TCM-20 light anti-aircraft gun



This TCM-20 twin 20-mm light anti-aircraft gun in the firing position has jacks lowered to the ground to provide a more stable firing platform. This system is essentially the old American M55 with its four 12.7-mm (0.50-calibre) M2 HB machine-guns replaced by two 20-mm cannon.

For some years Israel used the old American M55 trailer-mounted 12.7-mm (0.5-in) quadruple light anti-aircraft gun system, but they realized that it had a very short range. The RAMPTA Structures and Systems Division of Israel Aircraft Industries then modernized the system as the 20-mm **TCM-20** to meet the requirements of the Israeli Air Defence Command and, following trials with prototype systems, the type was accepted for service in time to be used in combat during the 1970 'War of Attrition', when it is claimed to have shot down 10 aircraft in 10 engagements. It was also used during the Yom Kippur War, when it is credited with shooting down some 60 per cent of enemy aircraft downed by air defences, the remaining 40 per cent being shot down by other anti-aircraft guns and HAWK surface-to-air missiles. In the 1982 invasion of the Lebanon the TCM-20 was used not only to shoot down Syrian aircraft and helicopters but also in urban fighting and to engage ground targets. The TCM-20 was offered on the export market at an early date and is now in service with at least six countries apart from Israel.

The TCM-20 is the M55 with the four 12.7-mm M2 HB Browning heavy machine-guns replaced by two Hispano-Suiza HS 404 cannon with a cyclic rate of fire of 650 to 700 rounds per minute, but a practical rate of fire of 150 rounds per minute. Each barrel has a quick-change drum magazine that holds 60 rounds of ready-use ammunition. The gunner aims the cannon with an M18 reflex sight. Turret traverse and weapon elevation are electric, with onboard power provided by two 12-volt batteries mounted at the rear of the carriage; the batteries are kept charged by an auxiliary power unit. In the firing position the wheels are normally removed and the carriage is supported on three levelling jacks.

The basic model is normally towed by any 4×4 light vehicle, although Israel also has in service a self-propelled model based on the M3 series halftrack. There is no provision for all-weather fire control, although warning of the exact direction of approach by enemy aircraft can be given by an Israeli-designed EL/M 2106 point-defence alerting radar.

More recently RAMPTA Structures and Systems has developed a new system called the **TCM Mk 3**, which appears to be similar in concept to the original TCM but can be fitted with a variety of different weapons in the 20-mm to 25-mm class, the example shown in 1983 being fitted with 23-mm cannon as used in the Soviet ZU-23 towed anti-aircraft gun system. In addition to the same M18 optical sight as installed on the original TCM-20, the TCM Mk 3 is being offered with a Starlight sight with a magnification of ×4 for night operations and a fire-control system that includes a laser rangefinder and computerized sight.

Specification

TCM-20

Calibre: 20 mm (0.79 in)

Weights: travelling 1350 kg (2,976 lb)

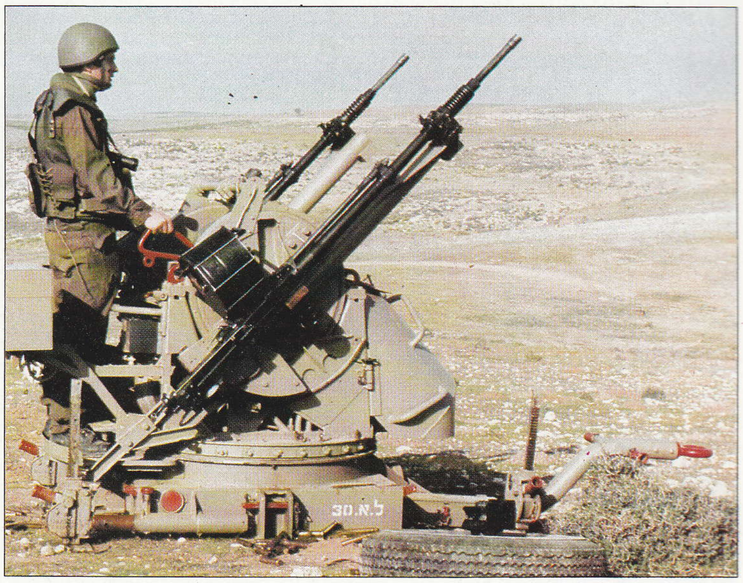
Dimensions: length travelling 3.27 m (10 ft 8.7 in); width travelling 1.70 m (5 ft 6.9 in); height travelling 1.63 m (5 ft 4.2 in)

Elevation: +90°/–10°

Traverse: 360°

Ranges: maximum horizontal 5700 m (6,234 yards); maximum vertical 4500 m (14,764 ft); effective vertical 1200 m (3,937 ft)

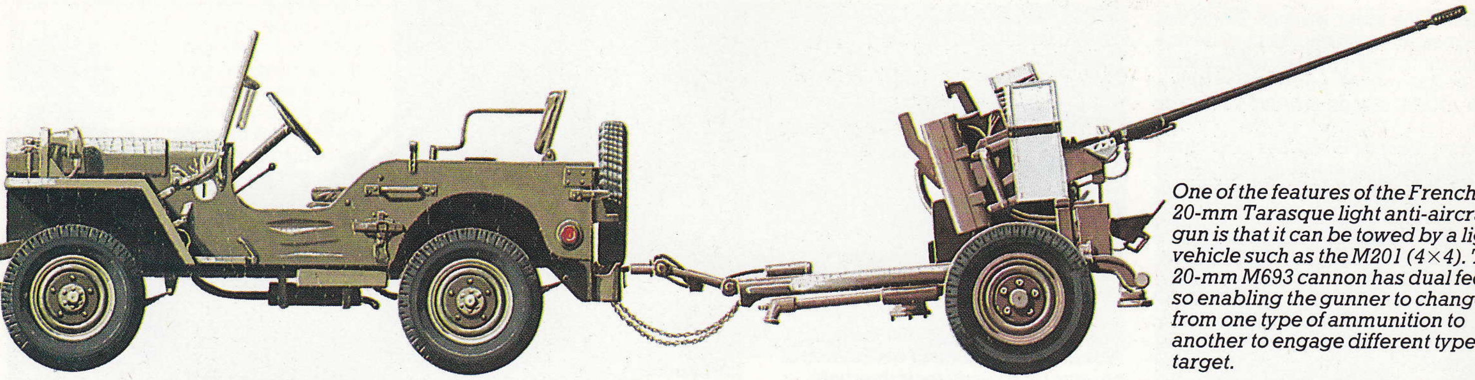
Crew: 4



At present there are two versions of the Israeli TCM-20 twin 20 mm anti-aircraft gun system: towed and self-propelled, with the latter being mounted on the rear of an M3 halftracked vehicle. The system was used for the first time during the so-called War of Attrition in 1970.

FRANCE

20-mm Tarasque light anti-aircraft gun



One of the features of the French 20-mm Tarasque light anti-aircraft gun is that it can be towed by a light vehicle such as the M201 (4×4). The 20-mm M693 cannon has dual feed, so enabling the gunner to change from one type of ammunition to another to engage different types of target.

The 20-mm **Tarasque** light anti-aircraft gun entered service with the French army several years ago under the designation **Type 53 T2**. It is armed with the 20-mm M693 cannon (the standard weapon of its type in the French army), which is also installed in the AMX-10P mechanized infantry combat vehicle and the AMX-30 main battle tank.

The Tarasque light anti-aircraft gun is carried on a two-wheeled carriage that can be towed by a light 4×4 vehicle such as the M201 or Land Rover. The weapon can be brought into action by two men in about 15 seconds: on arrival at the selected firing position the locking pin retaining the rear foot is removed and the mount slewed through 90° to place the other two feet in contact with the ground; the carriage is then removed and the mount supported on the three feet.

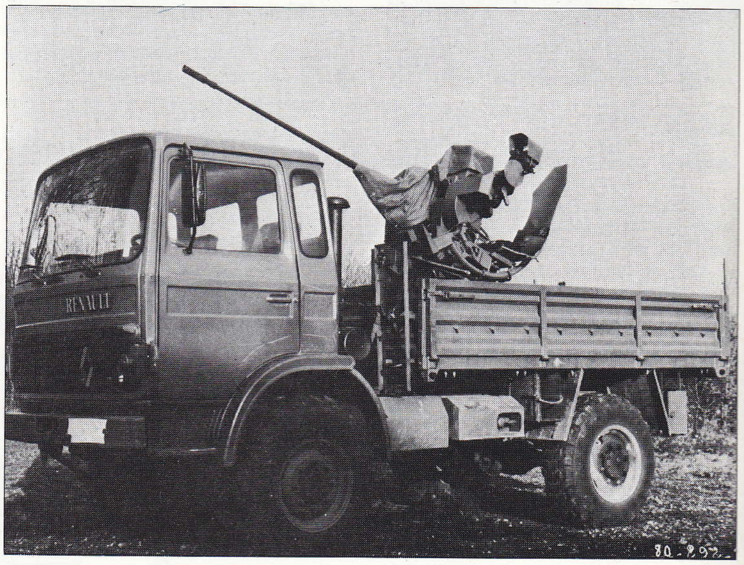
Only one man is required to operate the Tarasque gun, the other two men acting as ammunition handlers or aircraft spotters. The gunner is seated on the left side of the mount and moves in elevation with the 20-mm cannon. Elevation and traverse are hydraulic, though manual controls are provided for emergency use. Maximum traverse speed is 40° per second and maximum elevation speed is 80° per second.

The 20-mm M693 is a dual-feed cannon and has a cyclic rate of fire of 740 rounds per minute. The gunner fires the cannon by pressing down his right foot, and can fire single aimed shots or bursts. A total of 140 rounds of ready-use ammunition is carried, of which 100 are normally high explosive (HE) or high explosive incendiary (HEI) for engaging aerial targets, and 40 of armour-piercing discarding sabot (APDS) for engaging armoured targets. The latter round will penetrate 20 mm (0.79 in) of armour at an incidence of 0° at a range of 1000 m (1,094 yards).

The gunner has an anti-aircraft sight with a magnification of ×1 and a ground-to-ground sight with a magnification of ×5.

The Tarasque can also be installed, less its carriage, in the rear of cross-country vehicles such as the TRM 2000 4×4 truck; this gives the weapon greater cross-country mobility as well as enabling it to open fire as soon as the vehicle comes to a halt.

The French air force uses the twin 20-mm **Cerbère** light anti-aircraft gun to provide close protection for the Crotale surface-to-air missile systems protecting its air bases. The Cerbère, also known as the **Type 76 T2**, is essentially the West German Rheinmetall twin 20-mm light anti-aircraft gun with its original MK 20 Rh 202 cannon replaced by the French GIAT M693 cannon. Currently being tested for use with the Cerbère is the DALDO target indicator helmet: in this system the gun commander, situated away from the Cerbère, constantly scans the sky for a target. Once a hostile target has been selected the commander presses a button and the Cerbère mount is automatically laid onto the target in elevation and traverse, thus saving valuable seconds in target acquisition.



The GIAT 20-mm Tarasque light anti-aircraft gun can also be carried in the rear of trucks such as this Renault TRM 2000 (4×4) for greater cross-country mobility. This gun is now in wide-scale use with the French army and is also offered for export, as are most French weapons today.

More recently GIAT has developed a twin 20-mm light anti-aircraft gun system as a private venture. Designated **Type 53 T4** this weighs 2500 kg (5,512 lb), and is thus much heavier than the Cerbère or Tarasque. It has hydraulic elevation and traverse, and 150 rounds of ready-use ammunition for each of the 20-mm cannon.

Specification

Tarasque
Calibre: 20 mm (0.79 in)
Weights: travelling with ammunition 840 kg (1,852 lb); firing with ammunition 660 kg (1,455 lb)
Dimensions: length travelling 4.15 m (13 ft 7.4 in); width travelling 1.90 m (6 ft 2.8 in); height travelling 1.70 m (5 ft 6.9 in)
Elevation: +83°/–8°
Traverse: 360°
Ranges: maximum horizontal 6000 m (6562 yards); maximum vertical 4500 m (14,764 ft); effective vertical 2000 m (6,562 ft)
Crew: 3 (1 on mount)

YUGOSLAVIA

20-mm M55A2 light anti-aircraft gun

In recent years the Yugoslav defence industry has designed and placed in production a number of 20-mm light anti-aircraft guns, all of which use the same basic Hispano-Suiza 20-mm HSS-804 70-calibre barrel which is produced under licence in Yugoslavia.

The **20/1 mm M75** is the most unsophisticated weapon in the family, and has a single barrel with the gunner sitting on a seat at the rear of the mount. Elevation and traverse are manual, and the gunner aims the cannon at aircraft targets by means of an M73 reflex sight while a sight with a magnification of ×3.8 is used to engage ground targets. The cannon is normally fed from a drum holding 60 rounds of ammunition, but there is also a box type magazine that holds 10 rounds of ammunition; the latter is normally used for API, API-T and AP-T, while the drum magazine is used for the anti-aircraft rounds (HEI and HEI-T). The ammunition used by this gun is identical to that used in other weapons of this family.

The **20/3 mm M55A4 B1** has a carriage and sighting system similar to that of the Oerlikon-Bührle GAI-DO1 light anti-aircraft gun, and each of the three barrels has a 60-round drum magazine. The gunner sits on a seat at the rear of the mount, and power for the hydraulic elevation and traverse system is provided by a Wankel engine mounted under the gunner's seat. Maximum traverse and elevation rates are 80° per second.

Sighting is effected by an Italian Galileo P56 sight with a magnification of ×1 for use against aircraft and ×4 for use against ground targets. Each of the 20-mm cannon has a cyclic rate of fire of 700 rounds per minute, and the gunner fires the cannon by depressing a foot pedal. For transportation the mount is carried on a small two-wheel carriage, which in the firing position is supported on four outriggers.

The **20/3 mm M55A2** is very similar to the M55A4 B1 system, but has a different sight and manual elevation and traverse. The gunner is seated at the rear and has two handwheels (one for elevation and one for traverse), and fires the cannon by pressing a foot pedal. The gunner is provided with a sight for target tracking, but has to insert key data (for example target range and speed) manually to ensure a hit.

All of these 20-mm cannon are basically clear-weather systems with no provision for radar fire control. They are also offered for export, and sales have been made to a number of countries including Cyprus and Mozambique.

Specification

M55A2
Calibre: 20 mm (0.79 in)
Weights: travelling (with ammunition) 1100 kg (2,425 lb); firing (without ammunition) 970 kg (2,138 lb)
Dimensions: length travelling 4.30 m (14 ft 1.3 in); width travelling 1.27 m (4 ft 2 in); height travelling 1.47 m (4 ft 9.9 in)
Elevation: +83°/–5°
Traverse: 360°
Ranges: maximum horizontal 5500 m (6,015 yards); effective horizontal 2500 m (2,734 yards); maximum vertical 4000 m (13,123 ft); effective vertical 2000 m (6,562 ft)
Crew: 6 (1 on mount)

Low-Level Radar

Towed anti-aircraft guns depend on low-level radar for their efficiency; radar systems alert the batteries to the presence of hostile aircraft and direct the guns when the enemy is engaged. Today, systems such as Super Fledermaus are being superseded by extremely sophisticated equipment like the Swiss Contraves Skyguard.

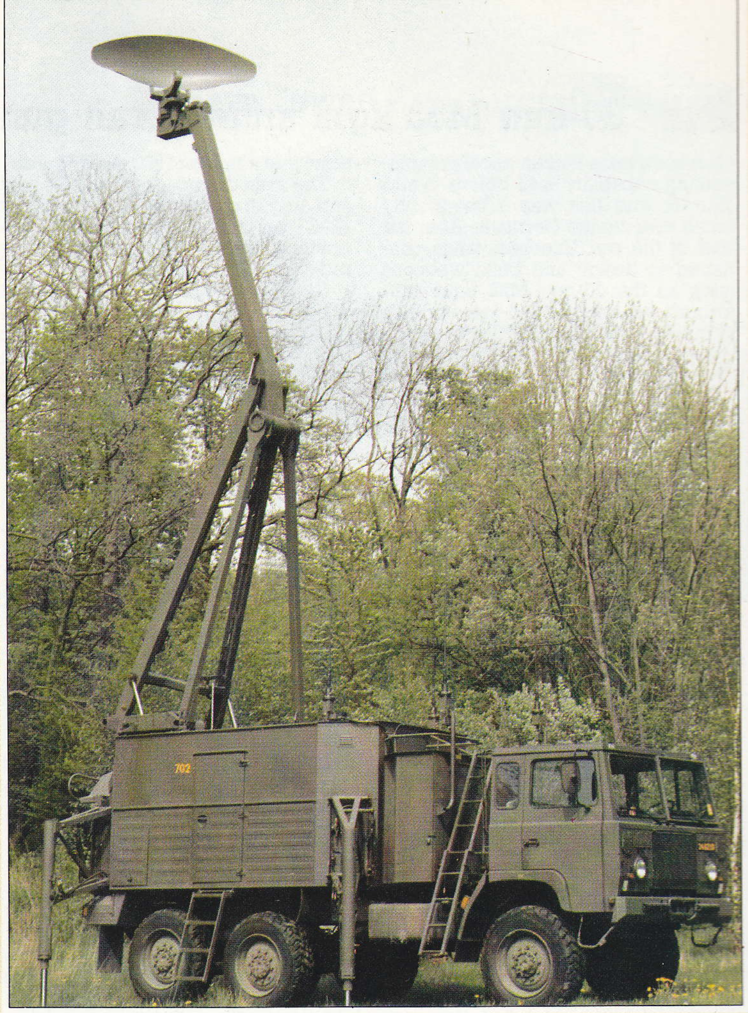
Most anti-aircraft guns are fitted with simple optical sights to enable them to engage both ground and air targets. The latter is, of course, the main objective of the towed anti-aircraft gun, but in the highly mobile type of warfare envisaged today, there will doubtless be occasions when the towed anti-aircraft gun will have to engage ground targets in order to survive.

To enable aerial targets to be engaged more effectively two distinct aids are now available, in the forms of an alerting radar and a fire-control system.

The alerting radar can be a tripod-, container- or vehicle-based system that is deployed fairly near the gun position. This continuously searches the sky for aircraft and helicopters, although the latter are particularly difficult to detect when they are hovering very near the ground. Once a possible target comes within range of the radar it appears on the radar operator's screen. Some of the more complex alerting radars have an identification friend or foe (IFF) system which enables the radar operator quickly to confirm if the target is friendly or hostile. If it is friendly no action is taken, but if it is confirmed as hostile the radar operator informs the anti-aircraft gun best positioned to engage the target of the approximate speed, height and direction of approach of the aircraft. The light anti-aircraft gun is then pointing in the general direction of the target as it comes into view.

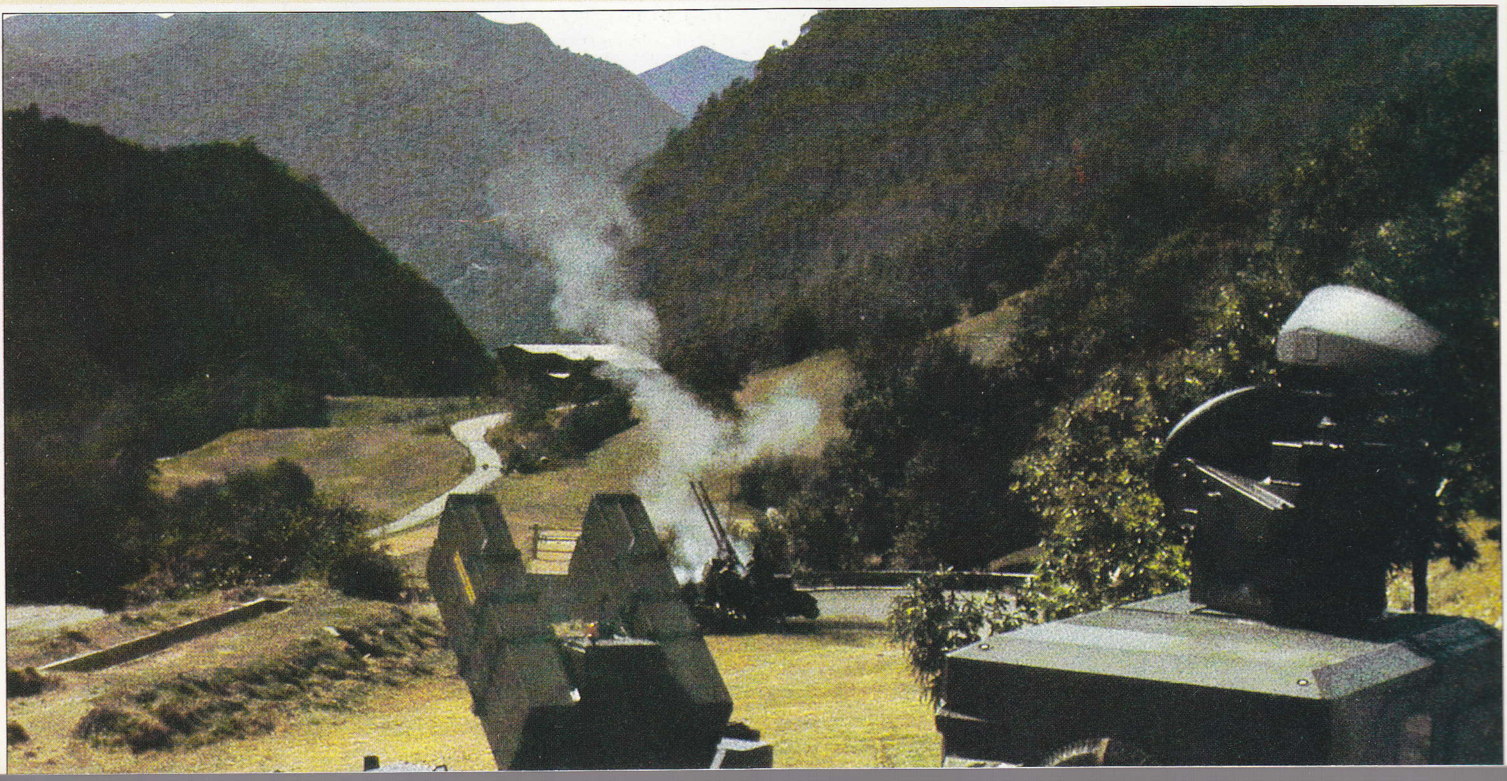
One of the more complex systems of this type is the Swedish Ericsson Giraffe search radar, which was originally developed to meet the requirements of the Swedish army for use with the Bofors RBS-70 surface-to-air missile system. The Giraffe radar system consists of a container which can be carried on top of a wide range of cross-country vehicles, tracked and wheeled. Mounted on top of the container is the radar on a hydraulic arm that can be raised to a height of about 12 m (39.4 ft) to improve its surveillance capabilities. The radar operators are seated inside the container, and once aircraft are confirmed as hostile RBS-70 missile launchers are allocated to each individual target. Target information can be transmitted to the RBS-70 launchers up to 5 km (3.1 miles) away from the Giraffe radar unit. Each RBS-70 unit has a target data receiver which can slew the RBS-70 launcher towards the target and inform the missile operator when the aircraft is within range. The Giraffe radar system is used by at least seven countries and can control light anti-aircraft guns as well as missiles.

One of the most comprehensive anti-aircraft fire-control systems available in the world today is the Swiss Contraves Skyguard, successor to the earlier Contraves Super Fledermaus system used by some 20 countries. The Skyguard fire control system is mounted in a fully air-conditioned trailer which can also be carried on a tracked (e.g. M548) or wheeled chassis for greater cross-country mobility. Although used mainly with anti-aircraft guns such as the Oerlikon twin 35-mm series, the Skyguard can also be used with missiles such as the Sparrow or a combination of guns and missiles.



The Swedish Ericsson Giraffe search radar was developed for use with the Bofors RBS-70 surface-to-air missile, but is also used to control light AA guns. From the back of the truck the operators can transmit target information to AA units up to 5 km (3 miles) away.

Targets are first tracked by the pulse-doppler search radar mounted on top of the container and then by the tracking radar or the TV tracking system, the latter being of considerable use in an ECM (electronic counter measures) environment. Inside the container is the control console, which can be operated by just one man, the computer and the data transmission system, which transmits information to the missiles or anti-aircraft gun. One Skyguard fire-control system typically controls two 35-mm Oerlikon towed anti-aircraft guns. The latter have just three men to keep the guns supplied with ammunition. The Skyguard fire-control system not only aims the gun accurately at the target but also makes them open fire when the target is within range, and also selects the number of rounds fired to ensure that the target is destroyed.



Experience has demonstrated that a complementary defence of guns and missiles provides the most effective protection against hostile aircraft. The enemy is forced low by the missile threat and then engaged by the guns. Here, Skyguard provides fire control information for both missiles and 35-mm Oerlikon AA guns.

CZECHOSLOVAKIA

30-mm M53 light anti-aircraft gun

Czechoslovakia had an excellent gun-making capability well before World War II, and this was subsequently taken over by the Germans. After the end of the war Czechoslovakia continued to design and build weapons such as the 30-mm **M53** light anti-aircraft gun, which it still uses in place of the Soviet 23-mm ZU-23. The Czech weapon is heavier and has a slower rate of fire, but it does have a more effective range than the ZU-23. In addition to being used by Czechoslovakia, it is also used by Cuba, Romania, Vietnam and Yugoslavia. There is also a self-propelled model called the **M53/59**, which is mounted on a modified and armoured Praga V3S 6×6 truck chassis. An unusual feature of the M53/59 is that the twin 30-mm weapons can be removed from the vehicle and placed on the ground for ease of concealment while the truck is driven away and camouflaged. The M53/59 is fed from vertical magazines holding 50 rounds, while the M53 is fed horizontally in 10-round clips.

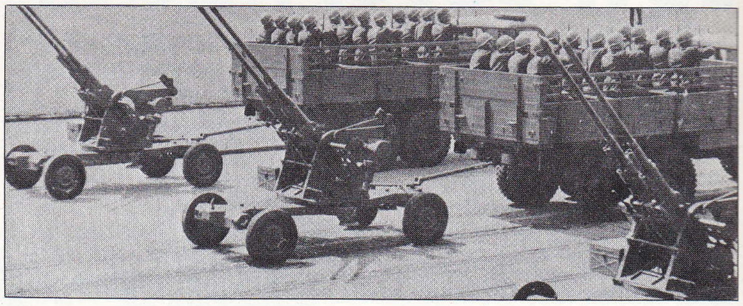
The M53 system is mounted on a four-wheeled carriage, no shield being provided for the four man crew. To provide a more stable firing platform in action, the wheels are raised off the ground and the carriage is supported by four jacks, one on each side on outriggers and one at each end.

The weapons are gas-operated, each having a cyclic rate of fire of 450 to 500 rounds per minute though the practical rate of fire is only 100 rounds per minute. Ammunition is fed to each barrel in clips, and two types of ammunition are available, both having a muzzle velocity of 1000 m (3,281 ft) per second: these are high explosive incendiary (HEI) and armour-piercing incendiary (API) for use against armoured vehicles. The latter round will penetrate 55 mm (2.17 in) of armour at a range of 500 m (547 yards).

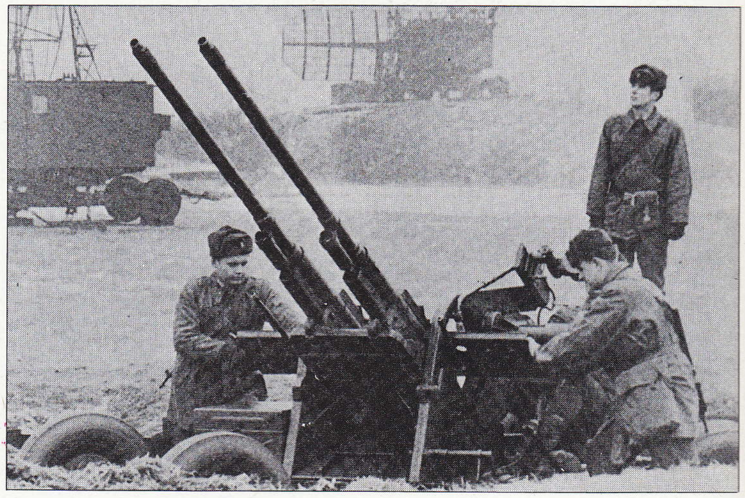
The main drawback of the M53 light anti-aircraft gun is that, like the Soviet ZU-23, it is limited to clear-weather operations as there is no provision for radar or off-carriage fire-control.

Czechoslovakia developed two other anti-aircraft weapons in the period after World War II, although as far as it is known neither remains in front line service with the Czech forces. These are the 12.7-mm (0.5-in) M53 quadruple anti-aircraft machine-gun, and a 57-mm anti-aircraft gun. The M53 is a two-wheeled carriage fitted with four Soviet DShKM machine-guns, each fed from a drum holding 50 rounds of ammunition. This weapon has an effective anti-aircraft range of 1000 m (1,094 yards) and is normally towed by a GA-69 4×4 truck which also carries its crew and a small amount of ready-use ammunition. The 57-mm anti-aircraft gun was used by the Czech army in place of the Soviet 57-mm S-60 and has a higher rate of fire, being fed with three- rather than four-round clips of ammunition. It is reported that this weapon was exported to a few countries including Cuba, Guinea and Mali.

Specification
M53
Calibre: 30 mm (1.18 in)
Weights: travelling 2100 kg (4,630 lb); firing 1750 kg (3,858 lb)
Dimensions: length travelling 7.587 m (24 ft 10.7 in); width travelling 1.758 m (5 ft 9.2 in); height travelling 1.575 m (5 ft 2 in)
Elevation: +85°/–10°
Traverse: 360°
Ranges: maximum horizontal 9700 m (10,608 yards); maximum vertical 6300 m (20,669 ft); effective vertical 3000 m (9,843 ft)
Crew: 4



Twin 30-mm M53 weapons are towed by a Praga V3S 6×6 truck. Ammunition is fed to each of the 30-mm barrels in clips of 10 rounds, with practical rate of fire being 100 rounds per barrel per minute. The M53 has no radar system, so is limited in its engagements.



The Czech twin 30-mm M53 light anti-aircraft gun is used here to defend a 'Bar Lock' air defence radar installation against air attack. In addition to this towed model there is also a self-propelled version called the M53/59, mounted on a 6×6 Praga V3S armoured truck chassis.

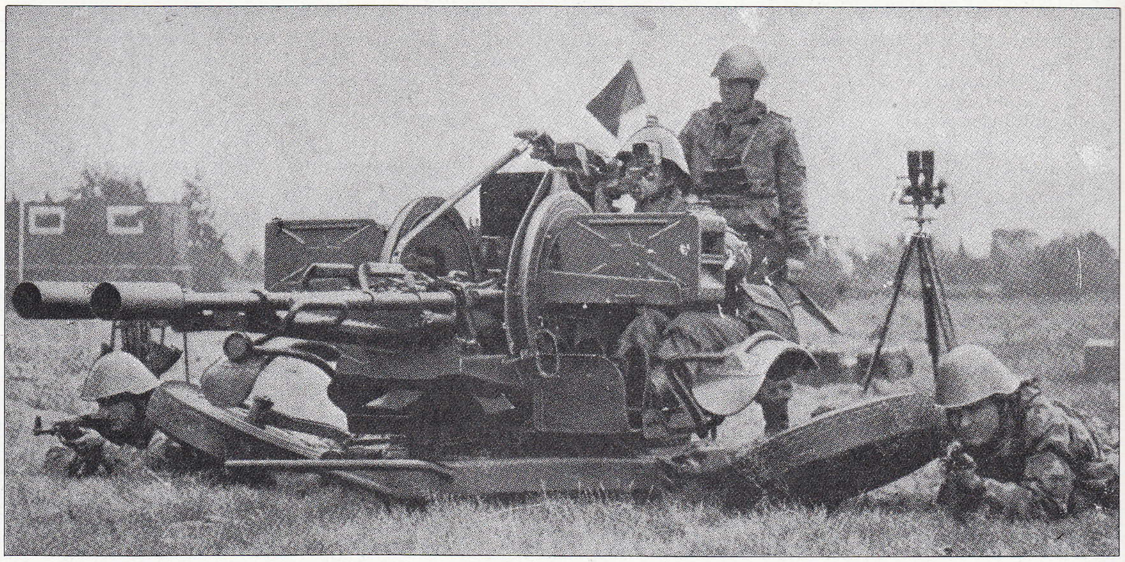
USSR

23-mm ZU-23 light anti-aircraft gun

For many years after the end of World War II the standard light anti-aircraft gun of the Soviet army was the ZPU series of 14.5-mm (0.57-in) weapons using the Vladimirov KPV heavy machine-gun, which even today is installed in turrets mounted on a number of Soviet armoured vehicles including the BRDM-2, BTR-60PB and OT-64. There are three basic models of the ZPU, the ZPU-1, ZPU-2 and ZPU-4, the numeral referring to the number of barrels. Although withdrawn from front-line service with the Soviet army some years ago, the ZPU series remains in service with about 40 countries around the world.

In the 1960s the ZPU series was replaced in the Soviet army by the **ZU-23** twin 23-mm towed anti-aircraft gun system, which is no longer in front-line Soviet use, so far as is known, having been replaced by surface-to-air missiles. At divisional level the last users were the airborne or airborne rifle divisions which each had a total of 24 systems, four in each of the three airborne rifle regiments and 12 in the divisional artillery element. The weapon is still used by some 20 countries, however, and was even encountered by United States forces during their invasion of Grenada in October 1983, when ZU-23 and ZPU series light anti-aircraft guns downed a number of American helicopters. In Afghanistan the Soviets have mounted a number of ZU-23s on the rear of trucks to provide suppressive ground-to-ground fire when convoys are attacked by guerrillas.

The ZU-23 is normally towed by a light vehicle such as the 4×4 GAZ-69, the Soviet equivalent of the Land Rover. The carriage has two rubber-tyred road wheels: in the firing position these wheels are raised off the ground and the carriage is supported on three screw-type levelling jacks. Each of the 23-mm barrels is provided with a flash suppressor, and a handle is mounted



A Soviet-built 23-mm ZU-23 light anti-aircraft gun of the East German army is seen in the firing position, showing the box of 50 rounds of ready-use ammunition for each barrel. The ZU-23 has been seen in Afghanistan mounted on the rear of cross-country trucks.

on top of each barrel to enable it to be changed quickly. Each barrel has a box of 50 rounds of ready-use ammunition, and though a cyclic rate of fire of 800 to 1,000 rounds per minute is possible, the practical rate of fire is 200 rounds per minute. Two types of fixed ammunition are fired by the ZU-23: armour-piercing incendiary-tracer (API-T) and high explosive incendiary-tracer (HEI-T), the former being used to engage armoured vehicles and the latter to engage aircraft. Both projectiles have a muzzle velocity of 970 m (3,182 ft) per second, and the API-T projectile will penetrate 25 mm (0.98 in) of armour at a range of 500 m (547 yards). The mounting has no provision for off-carriage fire control. The 23-mm cannon of the ZU-23 are also used in the famous 23-mm ZSU-23-4 self-propelled anti-aircraft gun system, although in this application the weapons are water-cooled to enable a higher rate of fire to be achieved.

More recently Egypt has been testing two versions of the M113 armoured personnel carrier with twin 23-mm anti-aircraft guns mounted on the roof, while Israel has captured a number of BTR-152 6×6 armoured personnel carriers from the PLO with a ZU-23 mounted in the rear.

Specification

ZU-23
Calibre: 23 mm (0.91 in)
Weights: travelling 950 kg (2,094 lb); firing 950 kg (2,094 lb)
Dimensions: length travelling 4.57 m (15 ft 0 in); width travelling 1.83 m (6 ft 0 in); height travelling 1.87 m (6 ft 1.6 in)
Elevation: +90°/–10°
Traverse: 360°
Ranges: maximum horizontal 7000 m (7,655 yards); maximum vertical 5100 m (16,732 ft); effective vertical 2500 m (8,202 ft)
Crew: 5

Although no longer in large-scale use with the Soviet Union the twin 23-mm ZU-23 light anti-aircraft gun system is still highly effective, and a number were used against American forces during the invasion of Grenada.

USSR

57-mm S-60 anti-aircraft gun

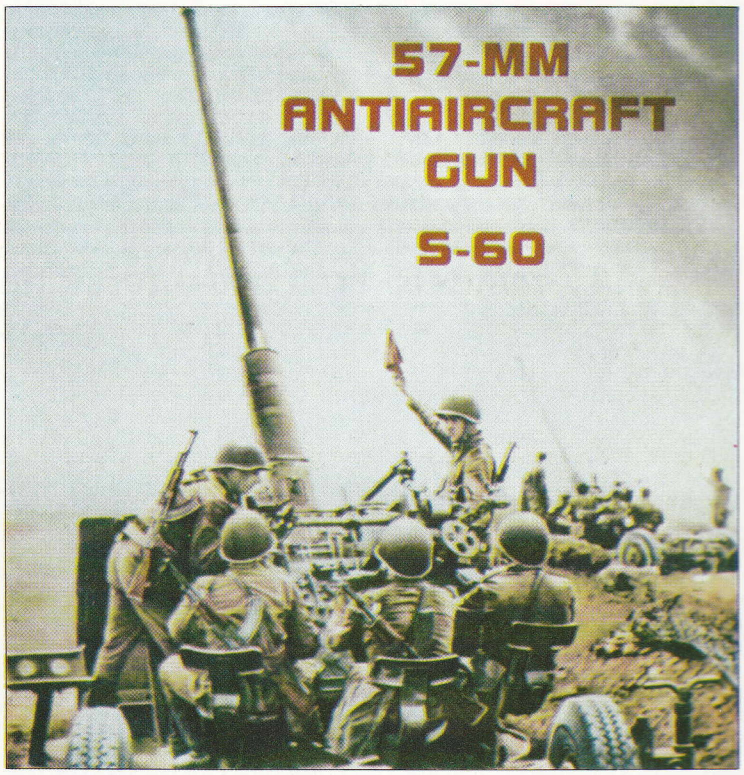
The 57-mm (2.24-in) **S-60** anti-aircraft gun entered service with the Soviet army after the end of World War II as the replacement for the 37-mm M1939 light anti-aircraft gun; this was the Soviet equivalent of the famous Bofors 40-mm L/60 weapon used in large numbers by the American and British armies during the war. Until very recently each tank division and motorized rifle division in the Soviet army had an anti-aircraft regiment equipped with the S-60. Each regiment had four batteries each with six guns, each battery having two three-gun platoons. Each battery had a SON-9/SON-9A 'Fire Can' fire-control radar, while at regimental HQ were two 'Flat Face' target-acquisition radars. More recently the 'Flap Wheel' radar has been used with the S-60 systemn.

The S-60 is still used by some 30 countries, especially in Africa, the Middle East and the Far East, and features in the inventory of most Warsaw Pact countries. In the Soviet army it has been replaced in many front-line units by the SA-8 'Gecko' surface-to-air missile (SAM), which in addition to being a much more effective all-weather system can be ready for action within seconds. China has built a model of the S-60 under the designation **Type 59**, while the ZSU-57-2 self-propelled anti-aircraft gun system uses the same ammunition as the S-60.

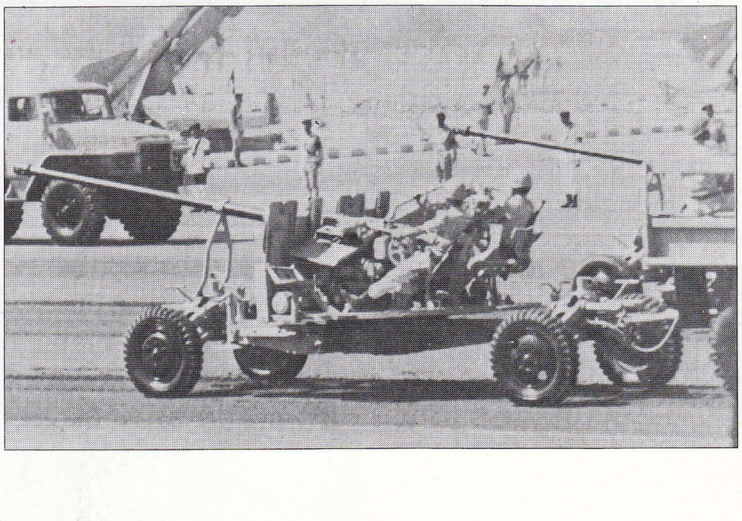
The S-60 can be towed by a variety of vehicles including 6×6 trucks such as the Ural-375D or the AT-L light tracked artillery tractors. The weapon can engage anti-aircraft targets with its wheels in contact with the ground, but it is much more accurate with its wheels raised off the ground and the carriage supported by four screw jacks, one on each side on outriggers and one at each end. Optical sights are fitted for the engagement of both ground and aerial targets. Four modes of operation are available: firstly, manual with the crew operating handwheels for elevation and traverse; secondly, power-assisted with the handwheels operated by the crews but assisted by a servo motor; thirdly, remotely-controlled by a Puazo series director and zero indicator; and fourthly, fully automatic and remotely-controlled by a director and zero indicator, plus radar. In each case ammunition is loaded in four-round clips by ammunition feeders, one clip being in the feed tray to the left of the breech and another clip on the mount itself. Three types of fixed ammunition can be fired by the S-60, all of which have a muzzle velocity of 1000 m (3,281 ft) per second: two types of fragmentation tracer (FRAG-T) and armour-piercing capped-tracers (APC-T). The latter will penetrate 96 mm (3.78 in) of armour at a range of 1000 m (1,094 yards). The S-60 has a cyclic rate of fire of 105 to 120 rounds per minute and a practical rate of fire of 70 rounds per minute.

Specification

S-60
Calibre: 57 mm (2.24 in)
Weights: travelling 4660 kg (10,274 lb); firing 4500 kg (9,921 lb)
Dimensions: length travelling 8.50 m (27 ft 10.6 in); width travelling 2.054 m (6 ft 8.9 in); height travelling 2.37 m (7 ft 9.3 in)
Elevation: +85°/–4°
Traverse: 360°
Ranges: maximum horizontal 12000 m (13,123 yards); maximum vertical 8800 m (28,871 ft); effective vertical with optical sights 4000 m (13,123 ft); effective vertical with off-carriage control 6000 m (19,685 ft)
Crew: 8



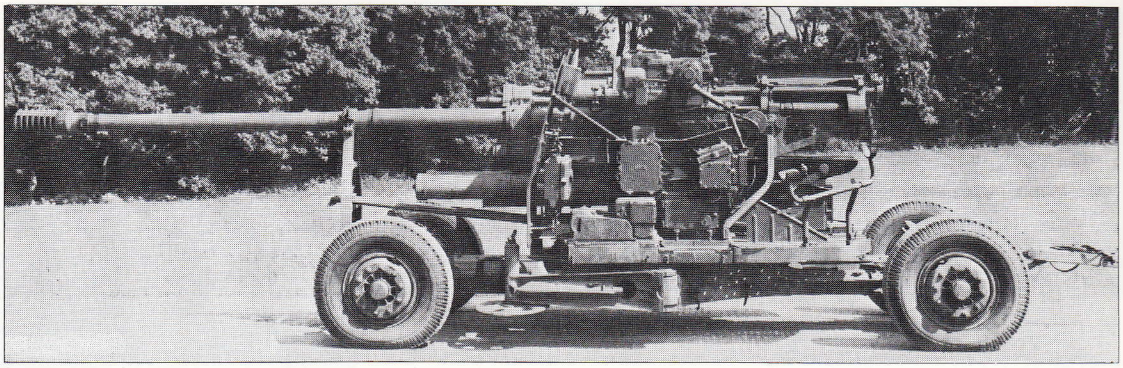
Right: The 57-mm S-60 anti-aircraft gun is highly effective when used together with the PUAZO-6/60 director and the SON-9/SON-9A radar, which is called 'Fire Can' by NATO. In 1985 Iraq was using the S-60 together with a low-light-level television system to engage Iranian aircraft.



For many years the 57-mm S-60 was one of the standard towed anti-aircraft guns of the Soviet army and was issued on the scale of 24 guns per division. This S-60 is of the Egyptian army and is in the travelling position, being towed by a 6×6 truck. In the Soviet army its replacement is the SA-8.

USSR

100-mm KS-19 anti-aircraft gun



The Soviet 100-mm KS-19 anti-aircraft gun was introduced some 40 years ago, but in Warsaw Pact countries has long been replaced in front-line service by missiles such as the SA-2 'Guideline'. The KS-19 is, however, still in widespread use in both the Middle and Far East.

One of the standard anti-aircraft guns of the Soviet army during World War II was the 85-mm (3.35-in) M1939, replaced in production by the M1944 which had a longer barrel and fired ammunition with higher muzzle velocity for increased range. In 1985 the M1939 and M1944 are still used by almost 20 countries, although in the Warsaw Pact they have been replaced by surface-to-air missiles. After the end of the war the Soviet Union introduced two new towed anti-aircraft guns, the 100-mm (3.94-in) **KS-19** and the 130-mm (5.12-in) KS-30; by 1985 neither of these remained in front-line service with the Soviet Union, although some 20 countries still use the KS-19 and two or three the much heavier KS-30. China has built the KS-19 under the designation **Type 59**.

The KS-19 is normally towed by an AT-S medium or AT-T heavy full-tracked artillery tractor, which also carries the 15-man crew and a small quantity of ready-use ammunition. The weapon is mounted on a two-axle carriage, and in the firing position the axles are raised off the ground and the carriage is supported by four screw jacks, one on each side on outriggers and one at each end of the carriage. When travelling the mount is traversed to the rear and the barrel is held in position by a lock.

The KS-19 fires ammunition of the fixed type which is loaded in single rounds from the left; to increase its rate of fire, the weapon is fitted with a single-round loading tray, automatic fuse setter and a power rammer. A well-trained crew can achieve a maximum rate of fire of 15 rounds per minute. Like most heavy-calibre anti-aircraft weapons, the KS-19 was designed as a dual-role (anti-aircraft and anti-tank) gun. Three types of ammunition, all with a muzzle velocity of 900 m (2,953 ft) per second, are available for the anti-aircraft role: high explosive, high explosive fragmentation and fragmentation. Two rounds are available for the anti-tank role: AP-T (armour-piercing tracer) and APC-T (armour-piercing capped tracer); the first of these has a muzzle velocity of 1,000 m (3,281 ft) per second and can penetrate 185 mm (7.28 in) of armour at a range of 1000 m (1,094 yards).

Anti-aircraft targets can be engaged with the sights installed on the KS-19, but better results are obtained with the PUAZO-6/19 director and the SON-9/SON-9A (NATO reporting name 'Fire Can') fire-control radar system. In most countries the KS-19 is used to defend strategic rather than tactical targets, and the weapon can be tied into an overall air-defence system. Lighter anti-aircraft guns, such as the 57-mm S-60, are used by field armies as they are easier to move about. The KS-19 has been used in action during the Korean War, the many wars in the Middle East, and also by North Vietnam against American aircraft.

Specification

KS-19
Calibre: 100 mm (3.94 in)
Weight: travelling 9550 kg (21,054 lb)
Dimensions: length travelling 9.45 m (31 ft 0 in); width travelling 2.35 m (7 ft 8.5 in); height travelling 2.201 m (7 ft 2.7 in)
Elevation: +85°/–3°
Traverse: 360°
Ranges: maximum horizontal 21000 m (22,966 yards); maximum vertical with time fuse 12700 m (41,667 ft); maximum vertical with proximity fuse 15000 m (49,213 ft); effective vertical 13700 m (44,948 ft)
Crew: 15

USA

12.7-mm M55 light anti-aircraft gun

The 12.7-mm (0.5-in) **M55** quadruple anti-aircraft gun system was developed in World War II by the Kimberly-Clark Corporation, and by the time production was completed in 1953 some 10,000 systems had been built. In addition to being used during World War II the M55 was used by the United States forces in both Korea and South Vietnam. In the latter conflict it was used in the ground fire-support role to break up mass attacks by Viet Cong on American supply bases and camps. Some M55 systems were also put on the rear of trucks and armour plated for use in the convoy escort role. In the US Army the M55 was replaced from the late 1960s by the 20-mm M167 Vulcan towed anti-aircraft gun system, but it is still used by almost 20 countries all over the world. More recently Israel has developed from the M55 the TCM-20 anti-aircraft gun system which has two 20-mm cannon in place of the four 12.7-mm (0.5-in) machine-guns of the original. The Brazilian company LYSAM has carried out a modernization of the M55 for the Brazilian army and has also fitted two 20-mm cannon in place of the four 12.7-mm machine-guns.

The M55 system consists essentially of two parts, the **M45C** mount and the **M20** trailer. The former is an armoured mount with a seat for the gunner and also contains an integral electric power unit which in turn is run from two 6-volt batteries. Mounted on each side of the mount are two 12.7-mm M2 HB machine-guns, each of which is fed from a belt containing 210 rounds of ready-use ammunition. The machine-guns are fully automatic and have a cyclic rate of fire of 450 to 550 rounds per barrel per minute, though the practical rate of fire is 150 rounds per barrel per minute. Types of ammunition that can be fired by the M2 machine-guns include armour-piercing (AP), armour-piercing incendiary (API), armour-piercing incendiary-tracer (API-T), incendiary, standard ball and training.

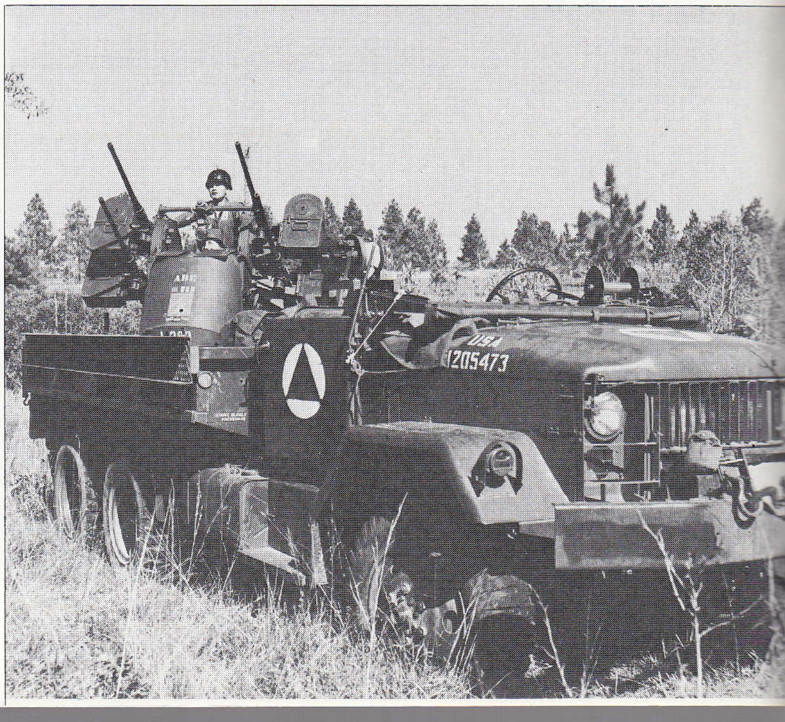
Turret traverse and weapon elevation are electric at a rate of 60° per second, the gunner using a pair of control handles which also accommodate the triggers. The weapons continue to fire as long as there is sufficient ammunition left and the triggers are depressed. The M55 is a clear-weather system only, and the gunner has a standard M18 reflex sight to his front that projects a graticule image on an inclined glass plate. The graticule image consists of four concentric circles, each corresponding to various aircraft speeds, and three dots on a vertical line in the centre of the field of view that are used to determine line of sight and compensate for gravity pull on the projectile.

The M20 two-wheeled trailer can be towed by a light vehicle but not at speeds above 16 km/h (10 mph), and for this reason the M55 is normally carried in the rear of a 6×6 truck such as the American M35. The weapon can be fired from the truck or unloaded onto the ground with the aid of two channels, one of which is carried on each side of the truck. On the ground the M55 is supported by three jacks (one at the front and two at the rear) and the small road wheels are removed.

During World War II two self-propelled models of the M55 were built, and some of these still remain in service in South America and elsewhere. The M16 was based on the M3 halftrack, while the M17 was based on the M5 halftrack.

Specification

M55
Calibre: 12.7 mm (0.5 in)
Weights: travelling 1338 kg (2,950 lb); firing 975 kg (2,150 lb)
Dimensions: length travelling 2.89 m (9 ft 5.8 in); width travelling 2.09 m (6 ft 10.3 in); height travelling 1.606 m (5 ft 3.2 in)
Elevation: +90°/–10°
Traverse: 360°
Ranges: effective horizontal 1500 m (1,640 yards); effective vertical 1000 m (3,281 ft)
Crew: 4



An American M55 quad 12.7-mm (0.50-calibre) anti-aircraft gun system is shown mounted in the rear of an M35 (6×6) truck. In addition to being used for the anti-aircraft role, it has also been used in the ground fire support role.

American Light AA Guns in the 21st Century

With renewed emphasis on rapid deployment divisions, the US Army is currently seeking a replacement for the M167 Vulcan system, its only towed anti-aircraft gun, as self-propelled AA guns like DIVAD can be transported by air only by using massive transport aircraft. One obvious answer would be to buy an existing European light AA gun but, as usual, the US defence industry is seeking to fill the gap itself.

Today the only towed light anti-aircraft gun in service with the US Army is the General Electric 20-mm M167 Vulcan, which entered service in 1967. This weapon, like its self-propelled counterpart, the M163, has no bad- or all-weather capability and lacks range. While the M163 is to be replaced in regular units by the twin 40-mm Sgt York Division Air Defense Gun (or DIVAD as it is more commonly known), no decision has been taken on replacement of the M167 Vulcan, which is used by the 82nd Airborne Division and the 101st Airborne Division (Air Assault), as well as by reserve units.

The recent decision to form a number of new light divisions capable of rapid deployment from the United States to any part of the world by transport aircraft such as the Lockheed C-5, C-141 and C-130 has led to a number of companies putting forward proposals for anti-aircraft weapons for these divisions. One of the early proposals was for a single barrel 40-mm system from Ford Aerospace and Communications Corporation, which is currently building the DIVAD system. This seems to have been discounted already as being too heavy. Some manufacturers are proposing existing weapons, such as Oerlikon-Bührle 25-mm Diana, while others are proposing new systems.

GE LADS

One of the more interesting systems being proposed is the GE LADS, or General Electric Lightweight Air Defense System, which is a further development of the private-venture GEMAG 25. The GE LADS system is mounted on a four-wheeled carriage which can be towed by light 4×4 vehicles such as the AM General HMMWV Hummer or carried underneath the Sikorsky UH-60 Black Hawk helicopter, already in service in some numbers.

The system is operated by one man, who sits in a fully-enclosed cabin on the left side. Mounted at the rear is a French Dassault surveillance radar which can detect and track two targets at a maximum range of 11 km (6.84 miles). If the target is hostile it would normally be engaged first by firing one of the six Stinger 'fire and forget' missiles mounted on the right of the system; close-in targets would be engaged by the GAU-12/U 25-mm dual-feed five-barrel cannon which has a cyclic rate of fire of 2,200 rounds per minute. The gunner can select either the latter rate of fire or 440 or 1,000 rounds per minute to conserve ammunition. The 25-mm ammunition used in the GE LADS is identical to the ammunition used in the Hughes Helicopters Chain Gun installed in the US Army M2 Bradley Infantry Fighting Vehicle and the US Marine Corps LAV-25. A total of 757 rounds of ammunition can be carried, and would normally be a mix of types to enable both air and ground targets to be engaged.

To extend the capabilities of the GE LADS even further, optional equipment includes a laser rangefinder, IFF (identification friend or foe) and automatic tracking. Built In Test Equipment (BITE) checks and monitors the system all the time that it is operating, so allowing faults to be located quickly and corrected.

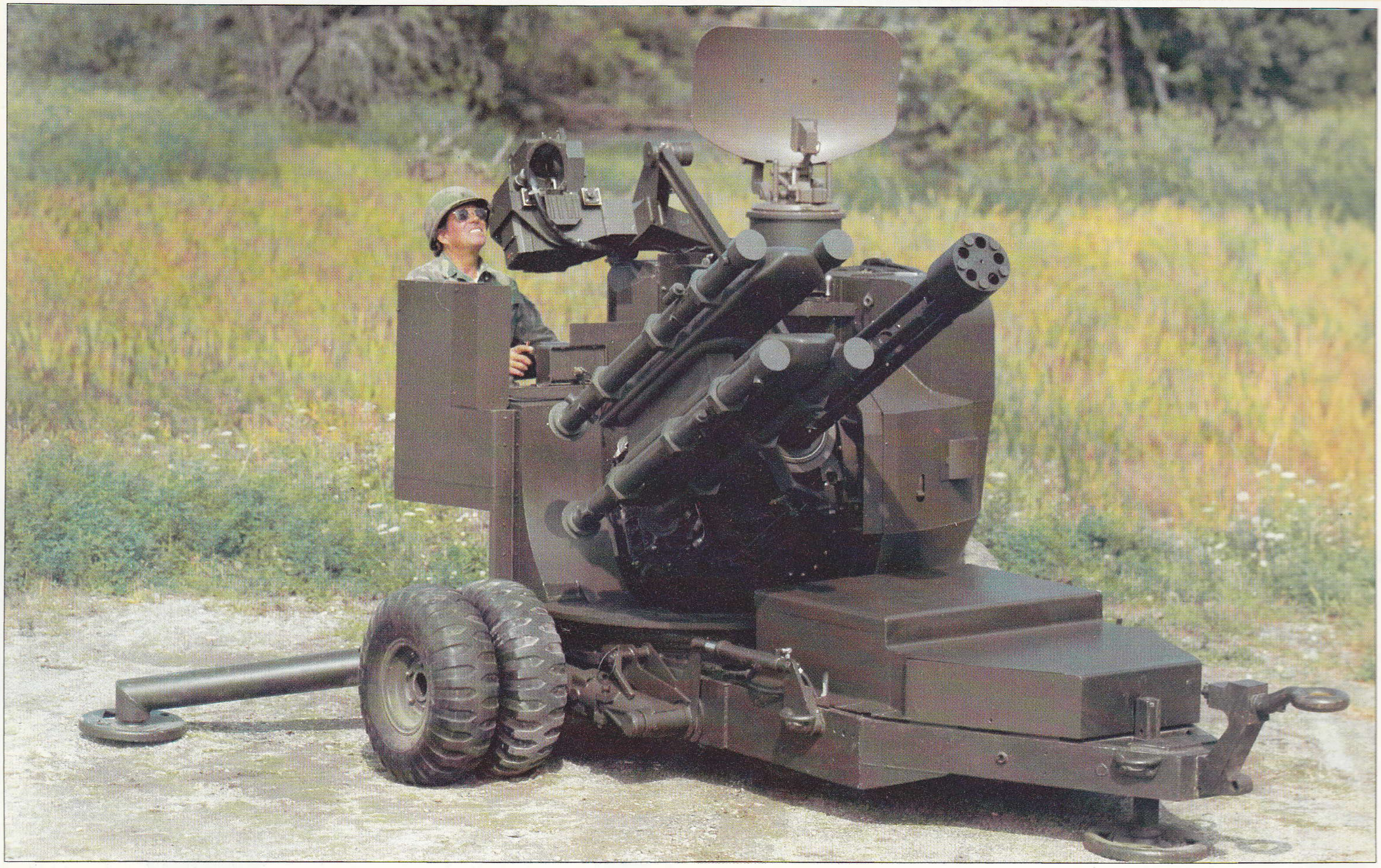
Boeing Avenger

Boeing has, as a private venture, developed a missile system called the Avenger which has already been tested by the 9th Infantry Division, which acts as a test bed formation for much of the equipment earmarked for Central Command and the new light divisions. The Avenger is a Hummer chassis fitted with a turret for eight General Dynamics Stinger missiles in the ready-to-launch position. During initial trials this has proved to be a highly effective system.

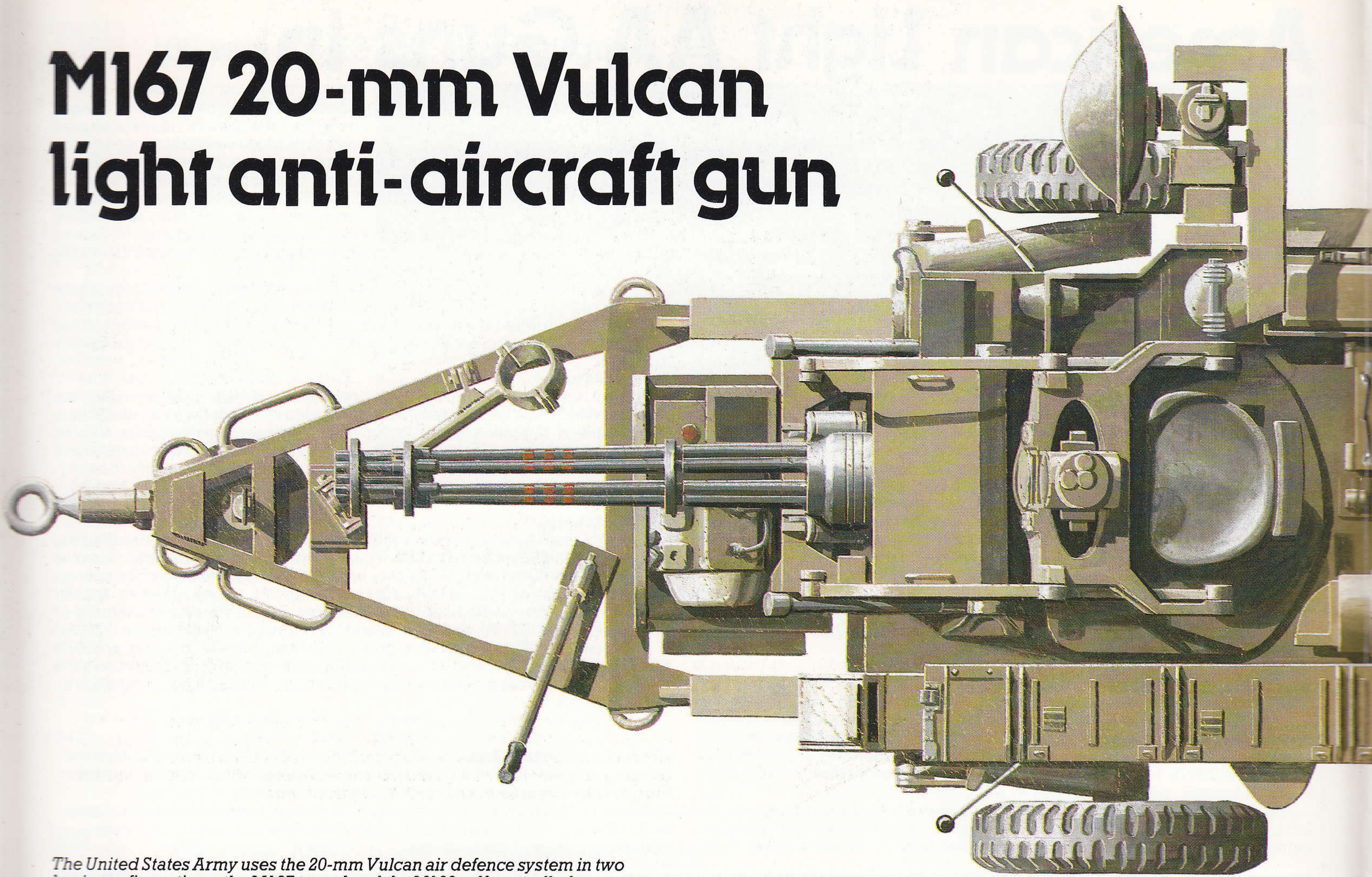
AMCTAC Setter

The US Army Missile Command and Tank Automotive Command unveiled the Setter air-defence system in 1984. This consists of an AM General Hummer with a roof-top turret armed not only with eight Stinger missiles but also six nine-round pods of high-velocity rockets which are highly effective against aircraft, helicopters and light armoured vehicles. The rockets have a velocity of about 1500 m (4,921 ft) per second and an effective range of about 1200 m (1,312 yards). A C-130 Hercules could carry three Setters, while a UH-60 Blackhawk can carry one as a slung load. An advantage of this system over the GE LADS is that it is a complete system in itself, the latter requiring another vehicle to tow it.

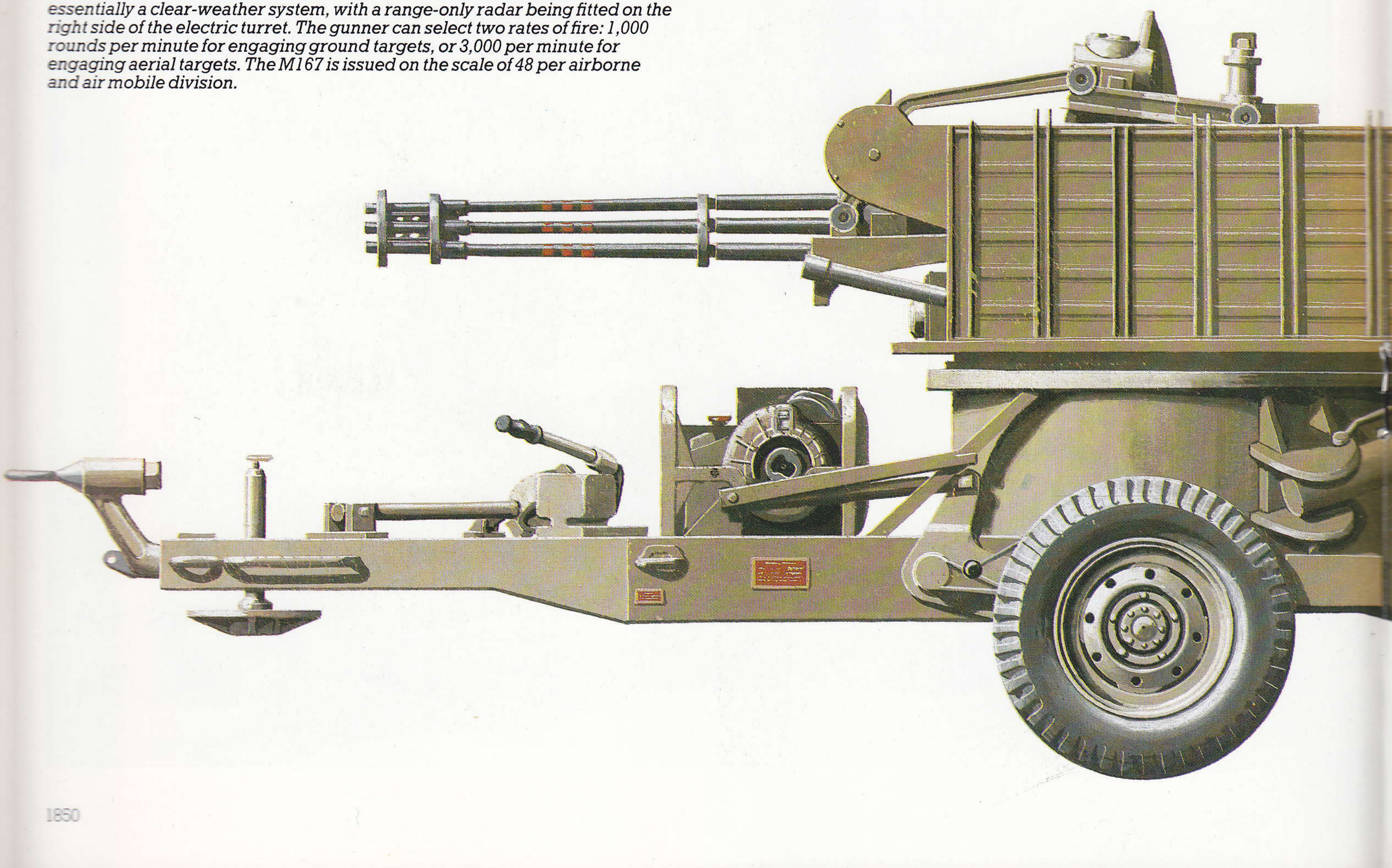
Currently being developed by General Electric, the GEMAG 25+ Air Defence System combines a 25-mm GAU-12/U gun and Stinger surface-to-air missiles. The gun has a dual feed, enabling it to switch from firing anti-aircraft ammunition to armour-piercing rounds for ground targets without changing belts. The fire control system allows for all-weather use, providing target acquisition out to 11 km (7 miles).

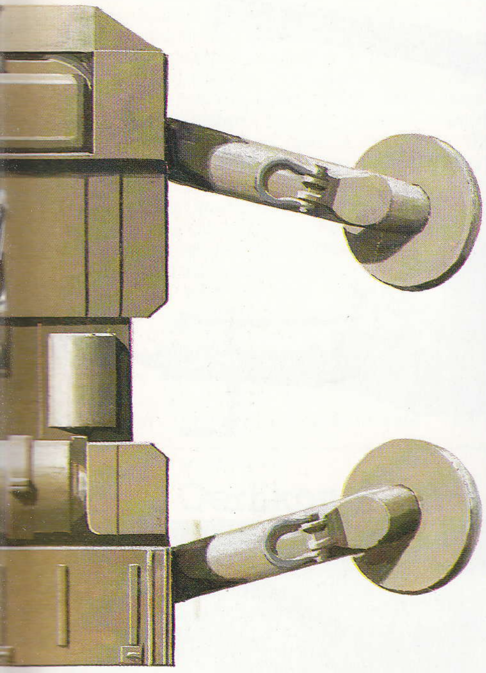


M167 20-mm Vulcan light anti-aircraft gun

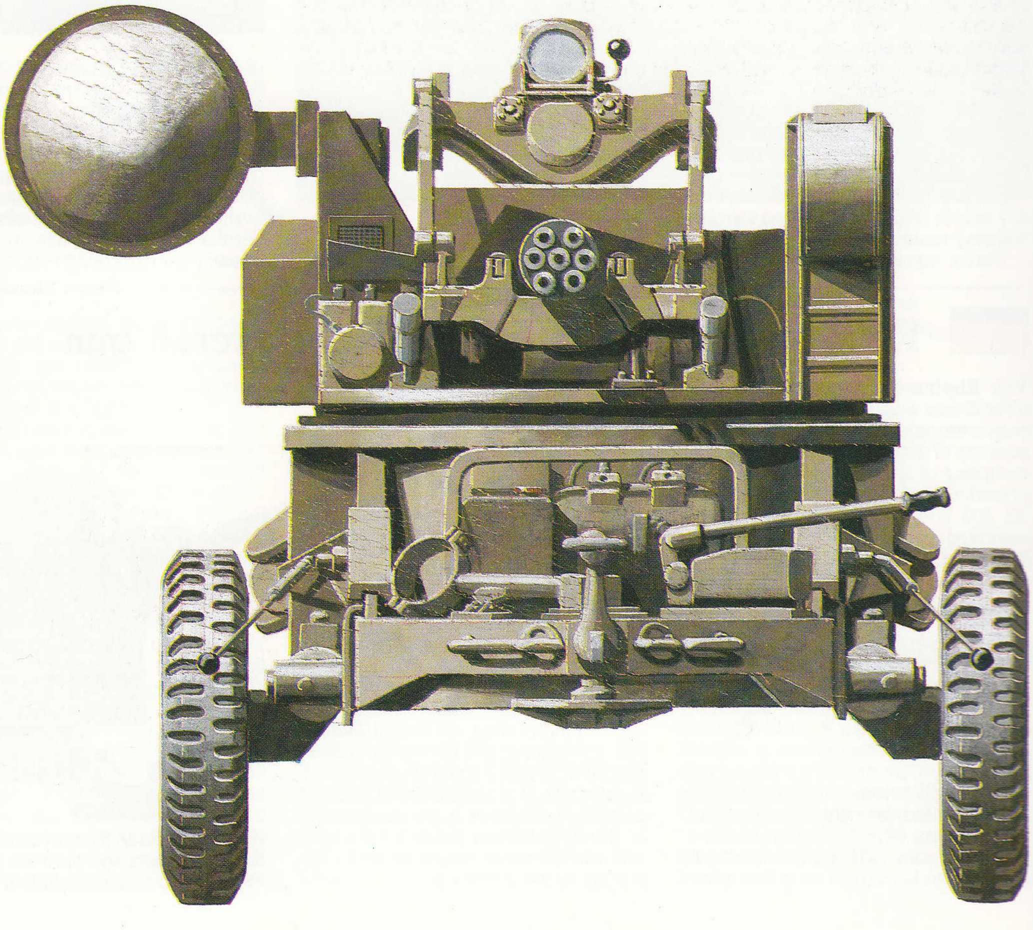


The United States Army uses the 20-mm Vulcan air defence system in two basic configurations, the M167 towed and the M163 self-propelled on a modified M113 full-tracked armoured personnel carrier chassis. Both are essentially a clear-weather system, with a range-only radar being fitted on the right side of the electric turret. The gunner can select two rates of fire: 1,000 rounds per minute for engaging ground targets, or 3,000 per minute for engaging aerial targets. The M167 is issued on the scale of 48 per airborne and air mobile division.



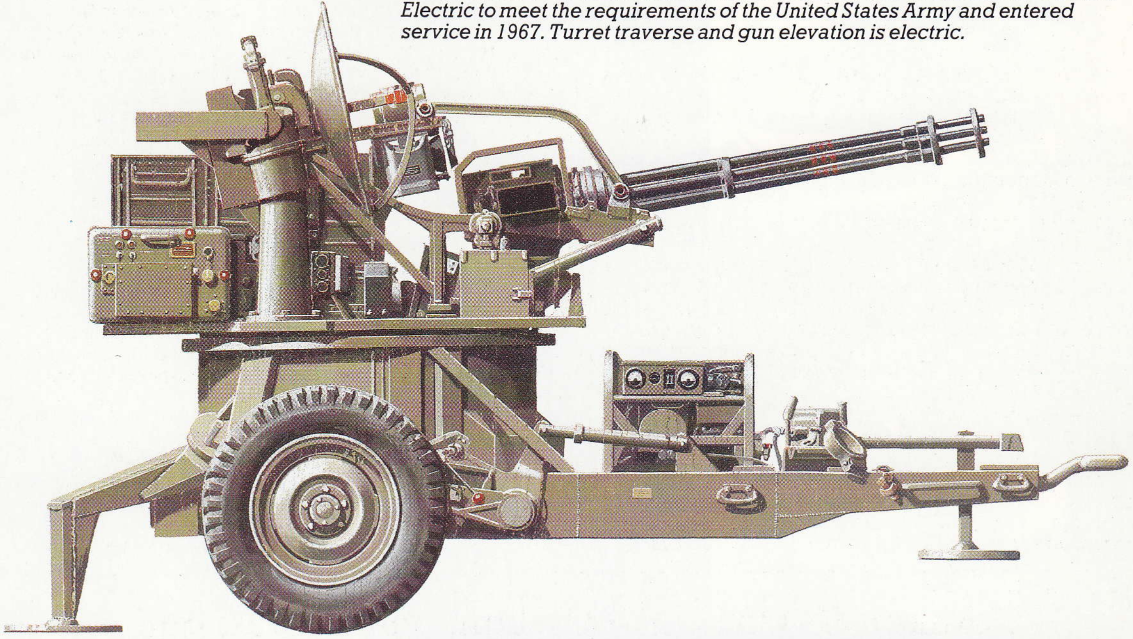


Nosing purposefully skyward, the six barrels of an M167 give no hint of the awesome power the Vulcan is capable of unleashing. At maximum rate of fire, some 50 rounds (which can be high explosive, HE incendiary, armour-piercing or tracer) are being launched each second, with an extremely high muzzle velocity (close to 1100 m/3,600 ft per second).



USA

20-mm Vulcan light anti-aircraft gun



The 20-mm M167 Vulcan light air defence system was developed by General Electric to meet the requirements of the United States Army and entered service in 1967. Turret traverse and gun elevation is electric.

In the early 1960s the General Electric Company developed two anti-aircraft gun systems to meet the requirements of the US Army. Both of these used the same 20-mm cannon developed from the M61 series installed in high-speed fighter aircraft such as the Lockheed F-104 Starfighter. After trials with both systems at Fort Bliss, Texas (home of US Army air defence), both weapons were accepted for service. The self-propelled system, mounted on a modified M113 series armoured personnel carrier chassis, is called the M163 and was the replacement for the 40-mm M42 Duster self-propelled anti-aircraft gun. The towed model, called the **M167**, was the replacement for the 12.7-mm (0.5-in) M55 quadruple machine-gun system developed in World War II.

The M167 is still in front-line service with the US Army, where it is employed with airborne and airmobile divisions. Each of these formations has one air-defence battalion with a battalion headquarters and four batteries. Each of the latter has a battery headquarters and three firing platoons each with four M167 systems. Although the self-propelled M163 is to be replaced in the regular army by the twin 40-mm DIVAD, no decision has been taken on what will replace the M167, which has limited range and no all-weather capability.

The M167 low-level air-defence system consists of a two-wheeled carriage on which is mounted an electrically-powered turret containing the 20-mm **M168 Vulcan** cannon, the linked-feed ammunition system, and the fire controls.

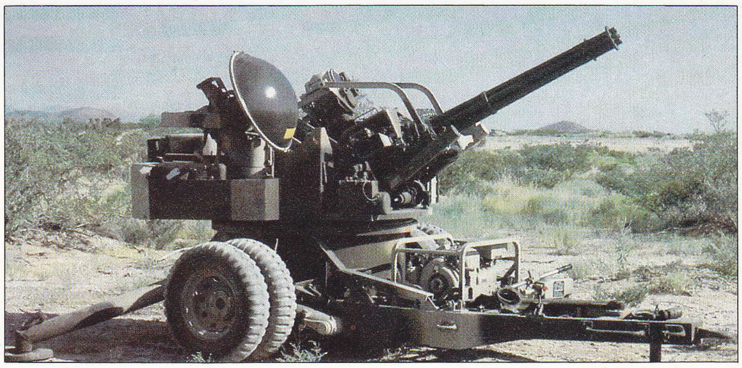
The M168 Vulcan cannon has six barrels and two rates of fire, 1,000 and 3,000 rounds per minute. The slower rate is normally used against ground targets, while the higher rate is reserved for aerial targets. To conserve ammunition, the gunner can select bursts of 10, 30, 60 or 100 rounds from the total of 300 or 500 ready-use rounds provided. Ammunition is of the fixed type and includes armour-piercing-tracer (AP-T), high explosive incendiary (HEI) and high explosive incendiary-tracer (HEI-T), as well as the usual training rounds.

Turret traverse and weapon elevation are electric, recharging being carried out by a generator installed on the forward part of the carriage. Turret traverse rate is 60° per second and weapon elevation rate is 45° per second.

The fire-control system on the M167 consists of a range-only radar on the right side of the mount, a sight current generator and a gyro lead-computing sight.

The M167 is normally towed by an M715 4×4 light truck and can also be slung under a helicopter. In addition to being used by the US Army, the M167 is also used by a number of other countries including Belgium, Ecuador, Israel, Jordan, Morocco, North Yemen, Saudi Arabia, Somalia, South Korea and Sudan.

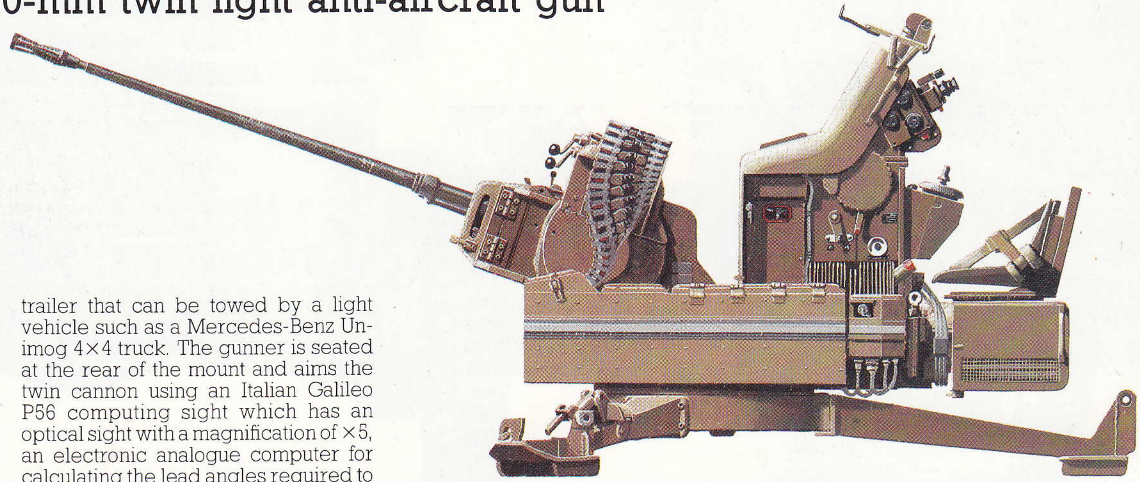
Specification
Vulcan
Calibre: 20 mm (0.79 in)
Weights: travelling 1588 kg (3,501 lb); firing 1565 kg (3,450 lb)
Dimensions: length travelling 4.906 m (16 ft 1.1 in); width travelling 1.98 m (6 ft 6 in); height travelling 2.038 m (6 ft 8.2 in)
Elevation: +80°/–5°
Traverse: 360°
Ranges: maximum horizontal 6000 m (6,562 yards); effective horizontal 2200 m (2,406 yards); maximum vertical 4500 m (14,764 ft); effective vertical 1200 m (3,937 ft)
Crew: 4-5 (1 on mount)



It is generally accepted that the 20-mm Vulcan anti-aircraft gun system has very limited capabilities. The M167 self-propelled model will be replaced by the 40-mm DIVAD, while the towed M163 will probably be replaced by a 25-mm gun or a new system combining a 25-mm gun and the Stinger missile.

WEST GERMANY

Rheinmetall 20-mm twin light anti-aircraft gun



A West German Rheinmetall twin 20-mm light anti-aircraft gun is seen in the firing position, showing the gunner's seat at the rear with the Italian Galileo P56 sight to his immediate front.

The **Rheinmetall 20-mm** light anti-aircraft gun was developed to meet the requirements of the West German ministry of defence by the Rheinmetall company of Düsseldorf. The mount is armed with two examples of the MK 20 Rh 202 20-mm cannon which is the standard weapon in its class in the West German army: it is also installed in the Marder mechanized infantry combat vehicle in a two-man power-operated turret; it arms the Wiesel light airportable armoured vehicle which has recently been ordered into production for West German airborne units; and it is fitted in a two-man turret on the Luchs 8×8 amphibious armoured car. The cannon is also installed on a single mount for various naval applications, and the Italians have installed the cannon in the FIAT/OTO Melara 6616 4×4 armoured car.

This 20-mm twin light anti-aircraft gun system is carried on a two-wheel trailer that can be towed by a light vehicle such as a Mercedes-Benz Unimog 4×4 truck. The gunner is seated at the rear of the mount and aims the twin cannon using an Italian Galileo P56 computing sight which has an optical sight with a magnification of ×5, an electronic analogue computer for calculating the lead angles required to hit aerial targets, a joystick for elevation and traverse, and a panel for inserting target information.

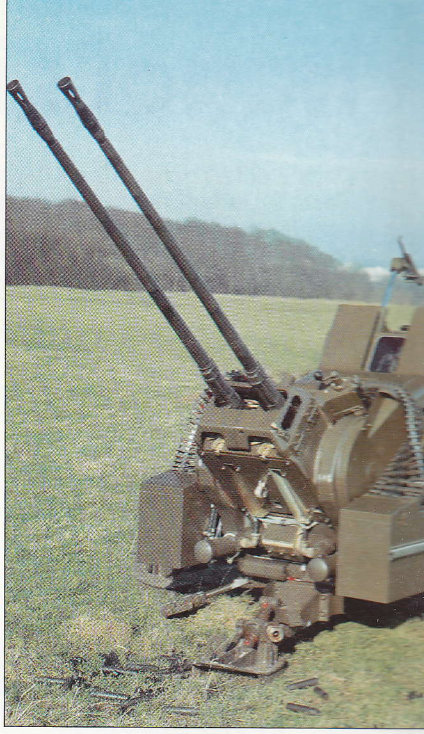
Rheinmetall 20-mm twin light anti-aircraft gun (continued)

Elevation and traverse are hydraulic, maximum traverse speed being 80° per second and maximum elevation speed 48° per second, power for these functions being obtained from an air-cooled two-stroke petrol engine mounted under the gunner's seat.

The cannon are gas-operated and fully automatic, the gunner firing them via a foot-operated pedal that is fitted with a safety device. The gunner can select either single shots or full automatic with either barrel or both together. The cannon have a cyclic rate of fire of 2,000 rounds per barrel per minute and each cannon is provided with an ammunition box containing 270 rounds of fixed ammunition, another 10 rounds being in the flexible feed system that connects the ammunition boxes with the gun. Types of ammunition that can be fired include armour-piercing discarding sabot-tracer (APDS-T), armour-piercing incendiary-tracer (API-T), high explosive incendiary (HEI), high explosive incendiary-tracer (HEI-T), and various training rounds. The APDS-T has a muzzle velocity of 1150 m (3,773 ft) per second.

In the firing position the weapon is supported on three outriggers. The system is essentially a clear-weather type, although it can be integrated into an overall defence system. In addition to being used by the West German armed forces it is also used by Argentina, Greece, Indonesia and Portugal. It was used by Argentina in the Falklands to defend Port Stanley airfield.

To meet the requirements of the Norwegian armed forces, Hispano-Suiza and A/S Kongsberg Vappenfabrikk designed and built a single-mount anti-aircraft gun called the **FK 20-2** which uses the same 20-mm cannon as the Rheinmetall twin 20-mm mount. This is used by the West German and Norwegian armies. In the future all of the 20-mm cannon of West Germany are expected to be replaced by the Mauser Model E 25-mm cannon, which was selected over the Rheinmetall Rh 205 25-mm cannon several years ago.



The Rheinmetall 20-mm MK 20 Rh 202 cannon is used in this twin anti-aircraft gun mount, the Marder MICV and the Luchs (8×8) reconnaissance vehicle. All of these guns will probably be replaced by the new Mauser Model E cannon, with longer range and improved ammunition.

Specification

Rheinmetall 20-mm mounting

Calibre: 20 mm (0.79 in)

Weights: travelling 2160 kg (4,762 lb); firing 1640 kg (3,616 lb)

Dimensions: length travelling 5.035 m (16 ft 6.2 in); width travelling 2.36 m (7 ft 8.9 in); height travelling 2.075 m (6 ft 9.7 in)

Elevation: +81.6°/–3.5°

Traverse: 360°

Ranges: maximum horizontal 6000 m (6,562 yards); maximum vertical 4500 m (14,764 ft); effective vertical 2000 m (6,562 ft)

Crew: 4-5 (but only 1 on mount)

SWITZERLAND

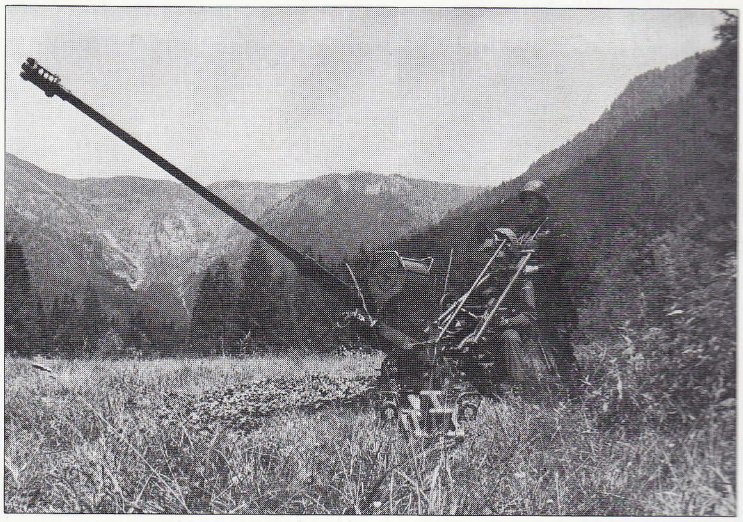
Oerlikon 20-mm GAI-BO1 light anti-aircraft gun

The Oerlikon-Bührle 20-mm **GAI-BO1** light anti-aircraft gun was originally called the **10 ILa/5TG**, the 5TG standing for the actual cannon, which was subsequently called the KAB-001.

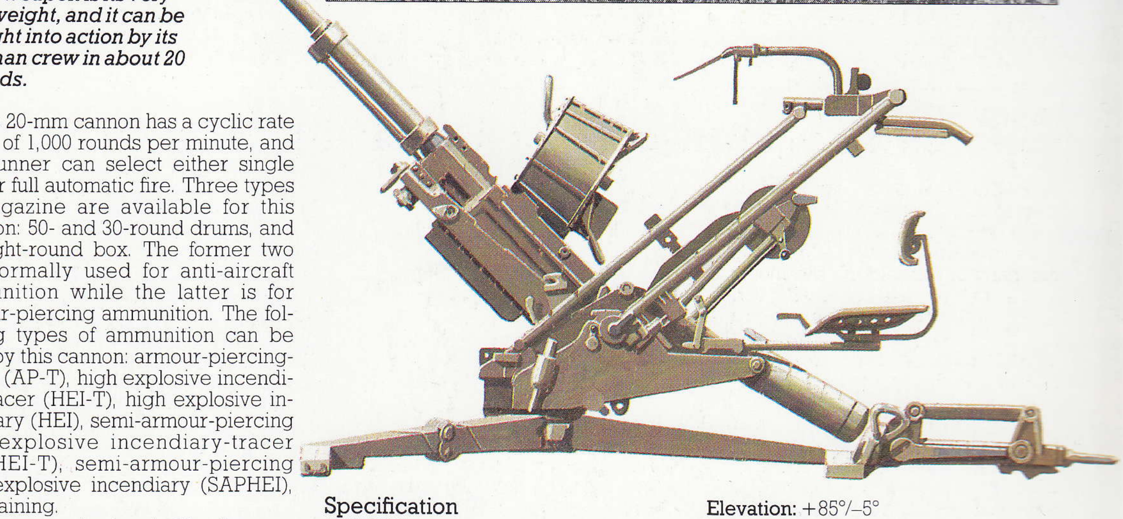
For many years Oerlikon-Bührle, now called Machine Tool Works Oerlikon-Bürhle and based in Zurich, was in competition with Hispano-Suiza which also built an extensive range of light anti-aircraft weapons and their associated ammunition. In 1972 Hispano-Suiza was taken over by Oerlikon-Bührle and some of the former's weapons were subsequently integrated into the Oerlikon range. The HS-666A twin 20-mm weapon became the GAI-DO1, the 20-mm HS-639-B 3.1 became the GAI-CO1, the HS-639-B 4.1 became the GAI-CO3 while the HS-639-B5 became the GAI-CO4. By 1984 all of these had been phased out of production although they remained in service with many countries; for example, the GAI-CO1 is used by both Chile and South Africa.

The 20-mm GAI-BO1 was the lightest Oerlikon-Bürhle weapon offered, although it too has now been phased out of service. It does, however, remain in use with many countries including Austria, South Africa, Spain and Switzerland. To provide greater mobility some countries have fitted the weapon in the rear of cross-country vehicles; for example, Austria has the weapon on the rear of the Steyr 6×6 vehicle with ready-use ammunition carried to the rear of the cab. The main drawback of systems such as the GAI-BO1 is that they rely on manual controls for elevation and traverse and therefore some operators find it difficult to track high-speed aircraft; no provision is made for radar fire control. Such systems do offer the advantage of being very light and can be disassembled into smaller parts for transportation in rough terrain where heavier weapons cannot be employed.

For travelling the GAI-BO1 is carried on a small two-wheeled carriage towed behind a light truck. The weapon can be brought into action in about 20 seconds, and is then supported on its outriggers.



For many years the 20-mm GAI-BO1 was the lightest in the extensive range of light anti-aircraft guns built by Oerlikon-Bührle. Traverse and elevation is manual, and drums of 20 or 50 rounds of ammunition can be fitted or a box holding just eight rounds.



An Oerlikon-Bührle 20-mm GAI-BO1 anti-aircraft gun is seen in the firing position. A key feature of this weapon is its very light weight, and it can be brought into action by its two-man crew in about 20 seconds.

The 20-mm cannon has a cyclic rate of fire of 1,000 rounds per minute, and the gunner can select either single shot or full automatic fire. Three types of magazine are available for this weapon: 50- and 30-round drums, and an eight-round box. The former two are normally used for anti-aircraft ammunition while the latter is for armour-piercing ammunition. The following types of ammunition can be fired by this cannon: armour-piercing-tracer (AP-T), high explosive incendiary-tracer (HEI-T), high explosive incendiary (HEI), semi-armour-piercing high explosive incendiary-tracer (SAPHEI-T), semi-armour-piercing high explosive incendiary (SAPHEI), and training.

The cannon is elevated by the gunner turning a handle, while traverse is obtained using the gunner's feet. An unusual feature of this weapon is that the gunner can also engage ground targets from the prone position; in this mode traverse is limited to 60° and elevation from –5° to +25°.

Specification

GAI-BO1

Calibre: 20 mm (0.79 in)

Weights: travelling 547 kg (1,206 lb); firing 405 kg (893 lb)

Dimensions: length travelling 3.85 m (12 ft 7.6 in); width travelling 1.55 m (5 ft 1 in); height travelling 2.50 m (8 ft 2.4 in)

Elevation: +85°/–5°

Traverse: 360°

Ranges: maximum horizontal 5700 m (6,234 yards); effective 2200 m (2,406 yards); maximum vertical 4500 m (14,764 ft); effective vertical 1500 m (4,921 ft)

Crew: 3 (1 on mount)

Hanoi's Ring of Steel

To protect Hanoi against US air raids the North Vietnamese installed the world's heaviest concentration of anti-aircraft guns, and soon added Soviet-supplied SA-2 surface-to-air missiles to these defences.

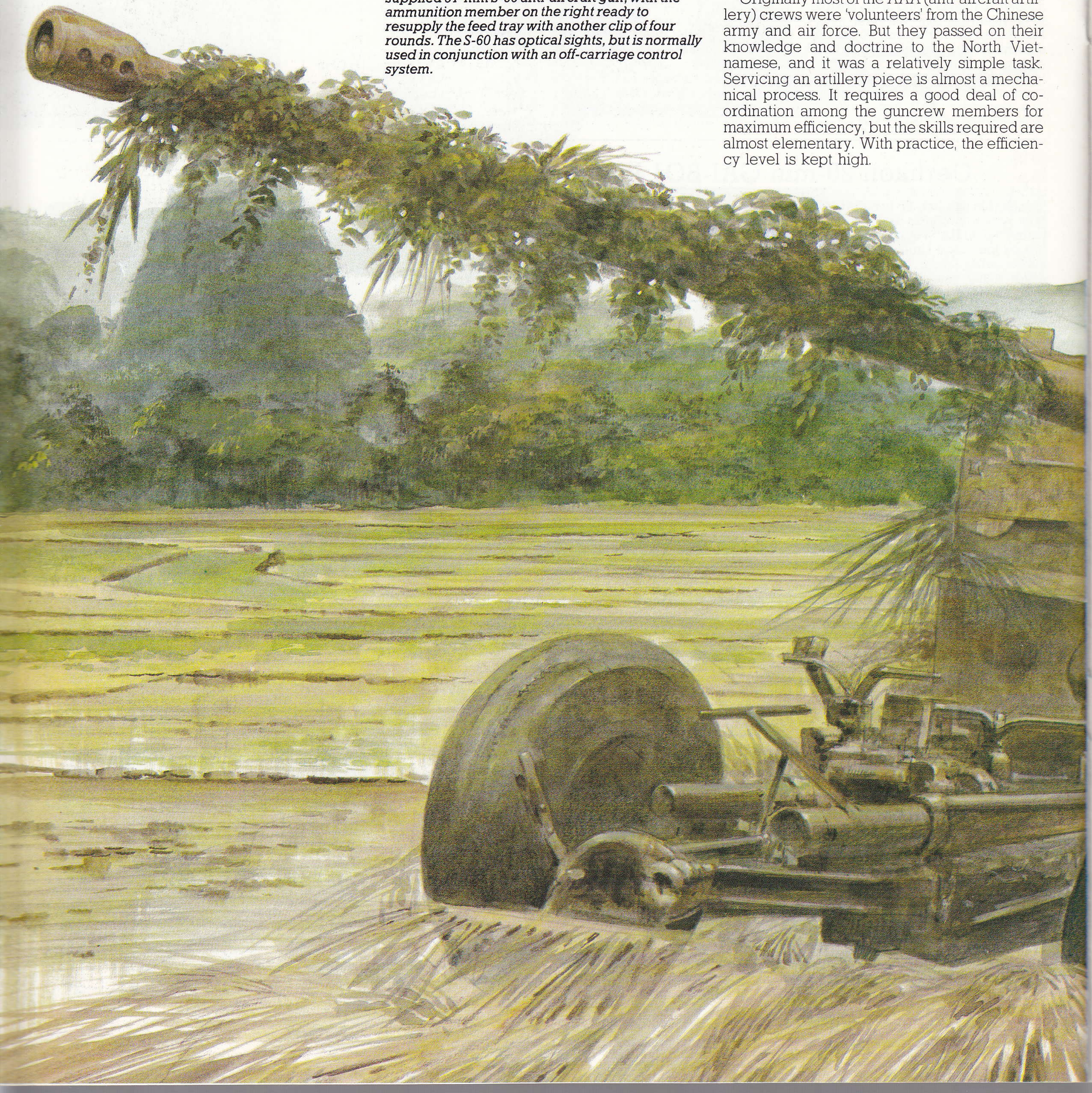
The US air offensive against North Vietnam was called Operation 'Rolling Thunder'. It lasted for more than seven years in an on-again, off-again fashion, pursued in vacillating manner by a Washington leadership uncertain of aims, objectives and methods. But the name of the bombing campaign, originating in a passage from an old gospel hymn, seemed to reflect the 'macho' egotism which characterizes tactical aviators the world over. The hymn is called 'How Great Thou Art'.

As 'Rolling Thunder' progressed by fits and starts, the US Air Force and Navy aircrews needed all the confidence they could muster. As a result of the American policy of gradualism ('escalation' or 'graduated response') the North Vietnamese had ample opportunity to increase their air-defence network and absorb valuable tactical lessons. The result was one of the best-defended pieces of geography on the planet.

The first US air strikes into North Vietnam were launched in August 1964 following the controversial Tonkin Gulf Incident. By early 1965 the North Vietnamese had barely 1,000 medium and heavy guns in calibres from 37-mm to 100-mm (3.94-in). By late summer the number had tripled, and by the end of 1966 there were between 6,000 and 7,000 guns of greater than 20-mm calibre in North Vietnam.

Few of these guns were radar-controlled, but they did not need to be. The lighter-calibre weapons were frequently mobile and could be towed to new sites with relative ease. Pure concentration was the name of the game; concentration and fire discipline.

Originally most of the AAA (anti-aircraft artillery) crews were 'volunteers' from the Chinese army and air force. But they passed on their knowledge and doctrine to the North Vietnamese, and it was a relatively simple task. Servicing an artillery piece is almost a mechanical process. It requires a good deal of co-ordination among the guncrew members for maximum efficiency, but the skills required are almost elementary. With practice, the efficiency level is kept high.



North Vietnamese gunners man their Soviet-supplied 57-mm S-60 anti-aircraft gun, with the ammunition member on the right ready to resupply the feed tray with another clip of four rounds. The S-60 has optical sights, but is normally used in conjunction with an off-carriage control system.

The North Vietnamese perfected the anti-aircraft gunner's art, though in truth it was more science than art. It was possible to compute with mathematical precision the amount of explosive per second required in a column of air to render an object flying through that column statistically vulnerable. The Communists' sector-fire technique was excellent, and they could fill a 13-km^2 (5-square mile) column with murderous flak from 1000 to 6000 m (3,280 to 19,685 ft).

Aircraft are not meant to duel with guns. Small arms and AAA accounted for by far the greatest portion of inflight losses during the Vietnam War, even computing unknown causes in the equation. Among US Navy aircraft, losses to gunfire amounted to 58 per cent of total losses on combat missions, including 77 per cent of shootdowns where the cause was definitely known.

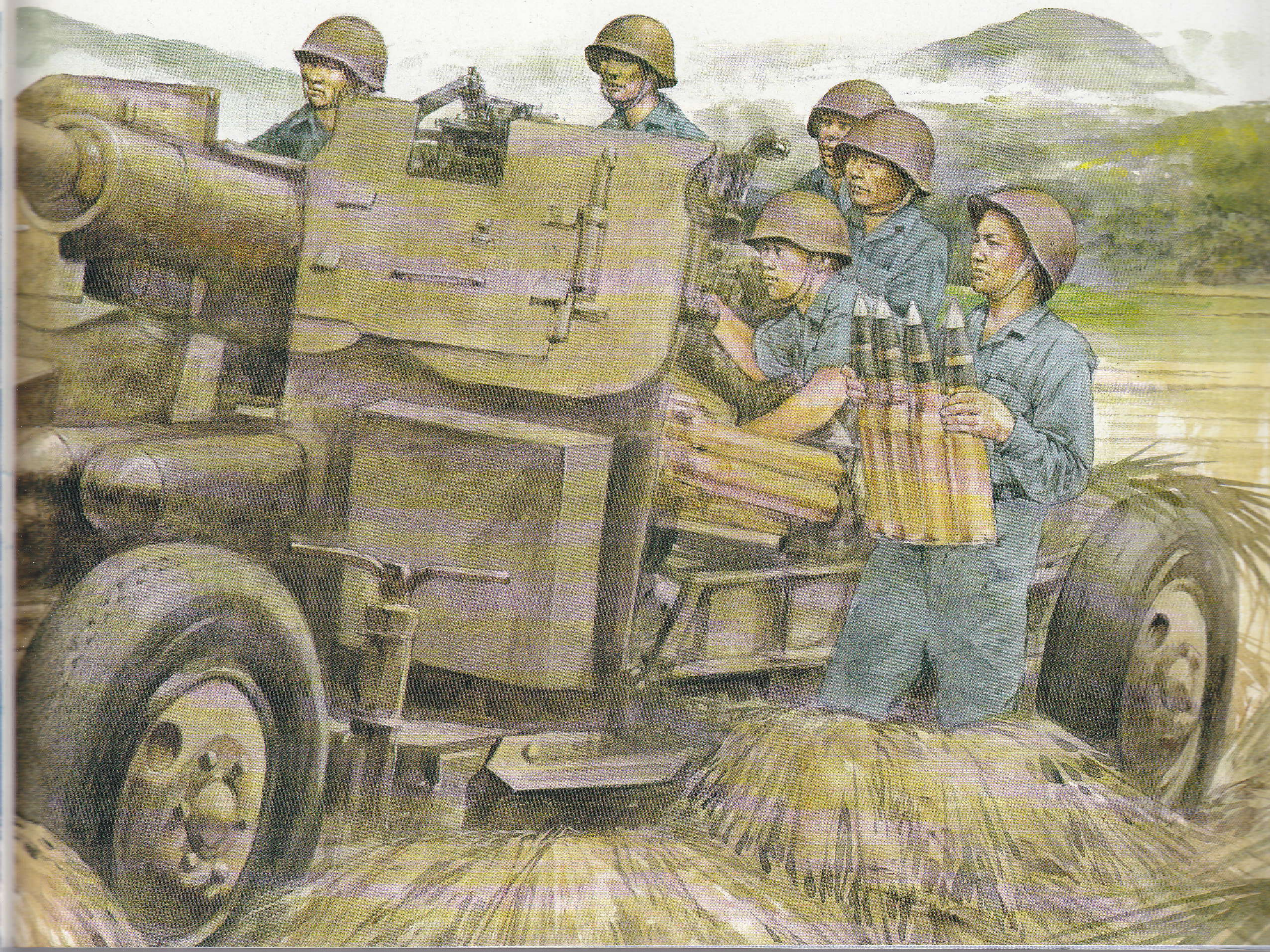
Small arms and flak took an even greater relative toll of US Marine Corps and Air Force planes. This was due partially to the fact that both services flew a great deal more over South Vietnam and Laos, where the only enemy threat was gunfire most of the time, but the figures are still daunting: 73 per cent of all USAF and 64 per cent of all 'Leatherneck' aircraft losses were definitely to guns.

In absolute terms these figures translated to roughly 1,600 fixed-wing aircraft shot down by small arms or AAA from the total 2,300 combat losses over Indo-China. Admittedly, not all were jets. The US Navy toll represented casualties in the spectrum from the Rockwell OV-10 to the McDonnell Douglas F-4, while the USAF's losses ranged from the little Cessna O-1 Bird Dog to the big, hulking Republic F-105. But neither the MiGs nor SAMs posed anything like as serious a threat as the thick clusters of AAA batteries in 'Route Pack Six' around Hanoi and Haiphong.

The first SA-2 site was detected south east of Hanoi in April 1965, and the Soviets announced the fact to the world in May. Yet despite this hard intelligence, no action was taken against SAM batteries until several had been completed. The USA lost its first warplane to the new threat on 24 July, when a USAF F-4C was shot down. The first counterblows came three days later, some three months after the missiles were known available to the North Vietnamese.

The SA-2 'Guideline' missile had been in service for at least eight years at this time. It was a well-tested, combat-proven medium-range weapon propelled by a booster rocket which burned for about five seconds after launch. The sustainer took over following booster separation and provided another 20 seconds of burn, which translated into a slant range of about 50 km (31 miles) and a ceiling of some 18000 m (59,055 ft).

Above: *The Soviet-supplied SA-2 'Guideline' surface-to-air missile was used in large numbers by North Vietnamese and succeeded in shooting down some American aircraft, including B-52 strategic bombers. It proved more effective in forcing tactical aircraft to fly much lower, where anti-aircraft guns could engage them.*



A North Vietnamese 57-mm S-60 anti-aircraft gun engages American aircraft carrying out a bombing raid. The air defences around Hanoi were so dense that American pilots renamed it Dodge City. These gun positions were well camouflaged and very difficult to spot from the air.

Nestled in the SAM's nose was a 130-kg (287-lb) warhead which could be fused for contact, proximity or command detonation. If the missile exploded within roughly 100 m (328 ft) of an aircraft it could cause lethal damage. A detonation inside 60 m (197 ft) almost certainly meant a kill.

The key to beating the SAMs was early sighting. For that reason, tactical aviators learned to avoid hugging cloud decks since the missiles could pop up through an undercast, homing on an aircraft completely unseen. In reasonable weather the telltale dustcloud indicating a launch was the best visual cue, quickly followed by the streaming white trail of the second stage.

But the missile was an aircraft, and the SA-2's small wings could not manage the *g* of a hard turn when approaching detonation range. Therefore, smart pilots always turned in two planes simultaneously to compound the problems inflicted on the missile's tracking. A barrel-roll type turn was optimum.

For all the publicity accorded SAMs during the war, they inflicted relatively few actual losses. Little more than 200 aircraft are known to have been shot down by SAMs between 1965 and 1972, of which about 120 were USAF machines. But regardless of numbers, SAMs played a constant and prominent role in dictating the conduct of strikes into North Vietnam. Aircraft inbound to worthwhile targets in 'Route Package Four' and 'Route Package Six' were usually within the envelopes of 30 or more SAM sites. By 1972 there were some 300 sites throughout the country, as far south as the Demilitarized Zone between North and South Vietnam, with 110 of them in and around the Hanoi-Haiphong area alone.

The missiles complemented the guns exceedingly well. By being forced into evasive action to defeat the SAMs, aircraft were usually drawn to the lower levels where gunfire became effective. With radar control and tracking, the North Vietnamese air-defence system benefited from long experience and American 'rules of engagement'.

For instance, once it became known that US fliers were prohibited from striking targets in or near civilian or populated areas, those locales became ideal battery sites. Guns and/or SAMs were sited on or near 'neutral' merchant vessels, on hospital roofs and even in the Hanoi soccer stadium.

Aside from the inevitable bombing errors, much damage was inflicted in downtown Hanoi from shells or SAMs falling to earth. Shell splinters or dud rounds were one thing; runaway SAMs at ground level were another! But the North Vietnamese seldom missed a chance to show such destruction as the handiwork of 'Yankee air pirates'.

To combat the AAA and SAMs, special weapons and aviators were sent to South East Asia. Among US Air Force tactical wings were the fabled 'Wild Weasels' flying two-seat F-105Fs, while McDonnell Douglas A-4 Skyhawks served a similar purpose on 'Iron Hand' duty from aircraft-carriers in the Tonkin Gulf.

The procedures were approximately similar for both US Air Force and Navy fliers. The SAM suppressors flew with or ahead of the strike group, waiting for an enemy radar to come 'up' and scan the formation. Communist radar operators became cagey, knowing that if they scanned very long they invited disaster. Consequently, an electronic cat-and-mouse game evolved, with airborne and ground operators trying to outwit one another.

If a SAM or AAA battery shifted from scan to tracking mode, the suppressor turned toward the immediate threat, gained lock-on, and fired a missile. This was the AGM-45 Shrike or, from 1968 onwards, the bigger and longer-ranged AGM-78. Homing on emissions from the enemy 'Fan Song' or 'Fire Can' radars, the Shrikes and Standard ARMs (Anti-Radiation Missiles) imposed a penalty for threatening US formations.

Nor were missiles the only threat. Aircraft such as the F-105, Vought F-8 Crusader and even the little A-4 armed with 20-mm cannon could and did put radar sites out of business.

In the end, it was not missiles or guns which defeated the North Vietnamese air-defence net. Rather, it was mines which closed Haiphong and other ports through which North Vietnam received the bulk of its war-making supplies. By the autumn of 1972, when the blockade had been in effect for several months, North Vietnam's arsenals were depleted. According to one unofficial source, there were perhaps fewer than two dozen SAMs left in the country when the Paris Accords were signed in January 1973. Meanwhile, aviators accustomed to pushing through walls of 57-, 85- and 100-mm flak found little more than 20- and 37-mm weapons to oppose them.

The ring around Hanoi had been broken.

SWITZERLAND

Oerlikon 20-mm GAI-DO1 light anti-aircraft gun

The Oerlikon-Bührle twin 20-mm **GAI-DO1** light anti-aircraft gun was originally designed and built by Hispano-Suiza under the designation **HS-666A**, and was the most sophisticated 20-mm weapon in the company's range. The main advantages of the GAI-DO1 over the other 20-mm light anti-aircraft guns manufactured by the company were powered elevation and traverse, a new sight, and two rather than one 20-mm cannon.

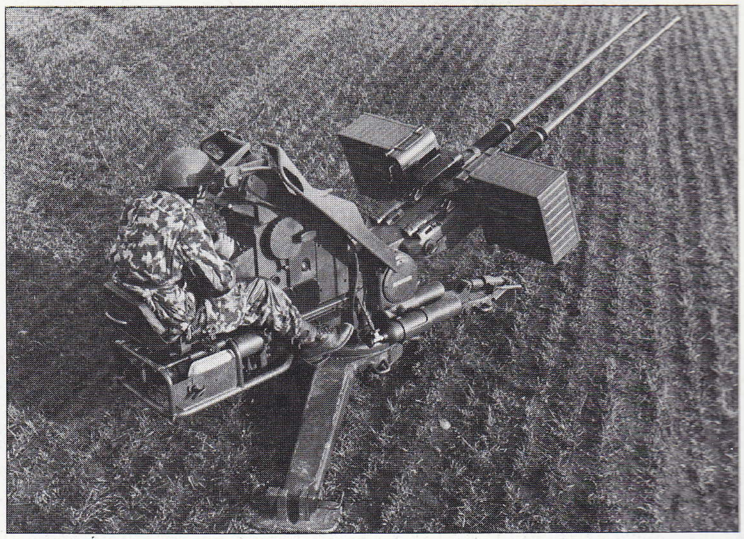
The system is fitted with two 20-mm KAD series cannon with a cyclic rate of fire of 1,000 rounds per minute per barrel. Each barrel is provided with a box magazine that holds 120 rounds of fixed ammunition. The gunner can select either single shots, rapid single shot, bursts or full automatic fire. The ammunition fired by the GAI-CO1 is identical to that of the GAI-BO1.

The gunner is provided with a shield, and mounted under the gunner's seat is the Wankel engine which provides hydraulic power for cannon elevation and mount traverse, maximum elevation speed being 48° per second and maximum traverse speed 80° per second. As with all powered anti-aircraft guns, manual controls are provided for emergency use. The gunner also has an Italian Galileo P56 sight which is identical to that installed on the Rheinmetall twin 20-mm light anti-aircraft gun used by the West German armed forces. This allows the gunner to engage ground and aerial targets with a high hit probability.

In the firing configuration the GAI-DO1 is supported on three adjustable feet, and for transportation it is carried on a two-wheeled carriage towed by a light truck. From its travelling position the weapon can be brought into action by its crew in less than one minute.

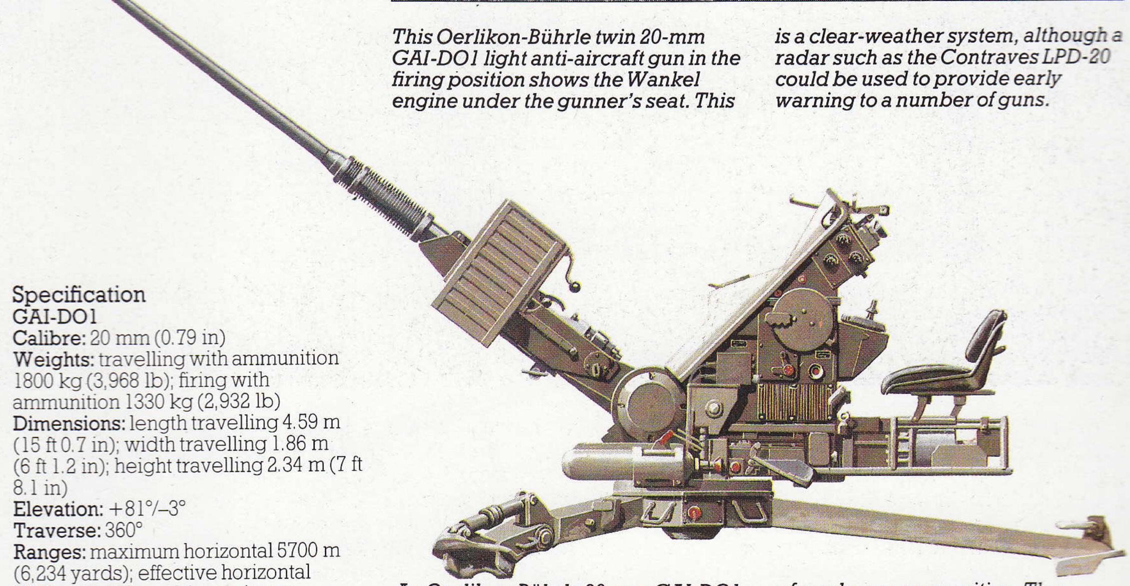
The basic GAI-DO1 light anti-aircraft gun is a clear-weather system, and therefore limited to daylight use; in conditions of low cloud its effectiveness is much reduced. The weapon can, however, be used in conjunction with the Contraves (Italy) LPD-20 search radar, which would provide the gun with target information such as range and speed.

Oerlikon-Bührle did offer a 25-mm anti-aircraft gun called the **GBI-AO1** with a single 25-mm KBA series cannon on a one-man mount with manual elevation and traverse. A feature of this weapon was that the dual-feed cannon was provided with two boxes of ammunition each containing 40 rounds, one holding armour-piercing discarding sabot-tracer (APDS-T) ammunition for engaging light armoured vehicles, and the other with high explosive incendiary-tracer (HEI-T) for engaging aerial targets. This weapon is no longer offered and is not known to have entered service in any quantity. In its place Oerlikon-Bührle is now offering the much improved Diana twin 25-mm light anti-aircraft gun.



This Oerlikon-Bührle twin 20-mm GAI-DO1 light anti-aircraft gun in the firing position shows the Wankel engine under the gunner's seat. This is a clear-weather system, although a radar such as the Contraves LPD-20 could be used to provide early warning to a number of guns.

Specification
GAI-DO1
Calibre: 20 mm (0.79 in)
Weights: travelling with ammunition 1800 kg (3,968 lb); firing with ammunition 1330 kg (2,932 lb)
Dimensions: length travelling 4.59 m (15 ft 0.7 in); width travelling 1.86 m (6 ft 1.2 in); height travelling 2.34 m (7 ft 8.1 in)
Elevation: +81°/–3°
Traverse: 360°
Ranges: maximum horizontal 5700 m (6,234 yards); effective horizontal 2200 m (2,406 yards); maximum vertical 4500 m (14,764 ft); effective vertical 1500 m (4,921 ft)
Crew: 5 (1 on mount)



An Oerlikon-Bührle 20-mm GAI-DO1 twin light anti-aircraft gun in firing position. Mounted each side of the 20-mm cannon is a box of 120 rounds of ready-use ammunition. The gunner aims the weapon using an Italian Galileo P56 sighting and an aiming unit containing a computer.

SWITZERLAND

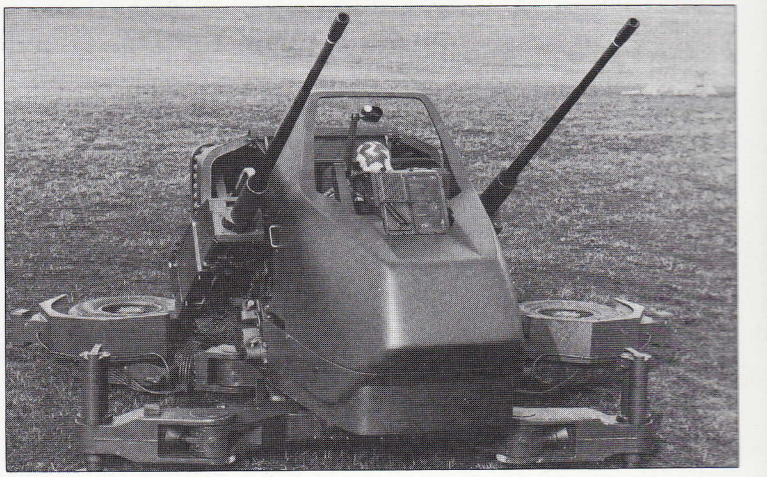
Oerlikon 25-mm Diana light anti-aircraft gun

The Swiss company Oerlikon-Bührle manufactures a wide range of 20-mm and 35-mm towed anti-aircraft gun systems, but some years ago realized that there was a gap between the most sophisticated 20-mm system (the twin GAI-DO1) and the twin 35-mm GDF series. To bridge this gap the company has developed the twin 25-mm **Diana** light anti-aircraft gun system, which has the company designation of the **GBF** series.

The Diana weighs only 2100 kg (4,630 lb) complete with ammunition, enabling it to be transported quickly by helicopters such as the Aérospatiale Puma or Sikorsky/Westland Sea King to where it is needed. The system is normally towed behind a light vehicle on its two-wheeled carriage. In the firing position the wheels are raised off the ground and the carriage is supported on three hydraulic jacks (one at the front and two at the rear) which can be adjusted to suit varying ground conditions.

So far two versions of the Diana are being offered, the **GBF-AOA** and the **GBF-BOB**. The first of these is armed with twin 25-mm KBA cannon, which is already used by four NATO countries installed in armoured vehicles and has a cyclic rate of fire of 570 rounds per barrel per minute. The 25-mm KBA fires five different types of ammunition: high explosive incendiary-tracer (HEI-T), semi-armour-piercing high explosive incendiary shell with tracer (SAPHEI-T), target practice with tracer (TP-T), armour-piercing discarding sabot-tracer (APDS-T), and armour-piercing practice-tracer (APP-T). The HEI-T is used to engage aerial targets while the APDS-T round is used against ground targets and will penetrate 25 mm (0.98 in) of armour at an angle of 30° at a range of 2000 m (2,187 yards). The GBF-AOA is fitted with the Italian P75 Galileo sight.

The GBF-BOB has the Oerlikon KBB cannon, which is also used on the Sea Zenith naval anti-missile defence system. The KBB has a longer barrel than the KBA, and fires ammunition with a



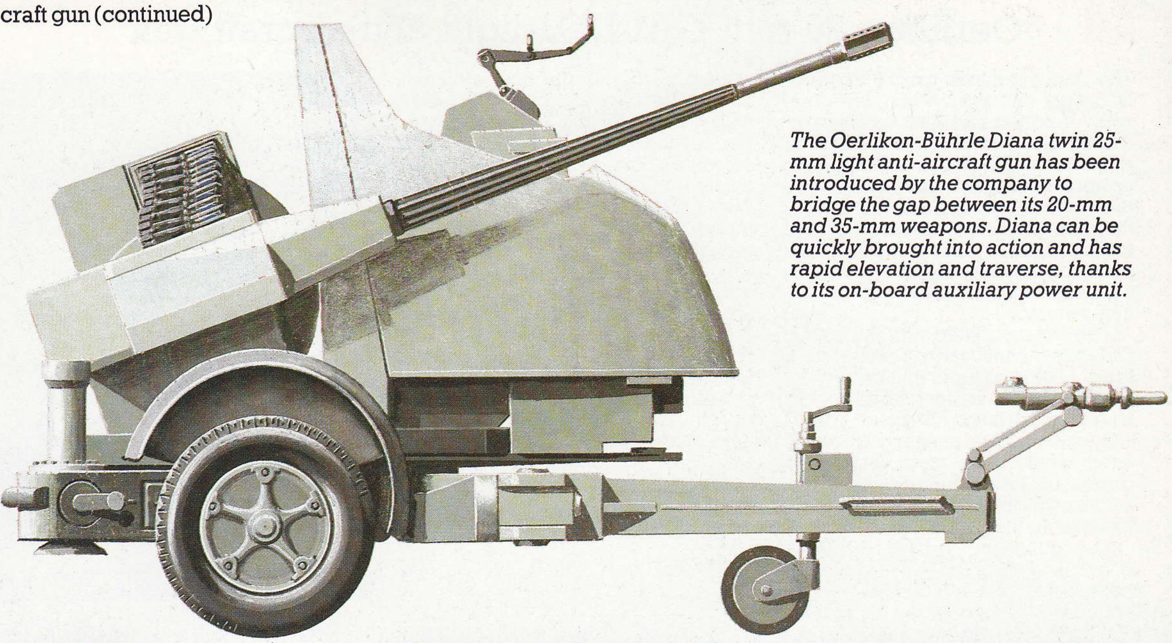
This Oerlikon-Bührle Diana twin 25-mm light anti-aircraft gun system, in the firing position shows the wheels raised clear of the ground. Each cannon has a dual-feed system enabling the gunner to switch from one type of ammunition to another to engage either ground or air targets.

Oerlikon 25-mm Diana light anti-aircraft gun (continued)

higher muzzle velocity and therefore greater target penetration. The GBF-BOB also has the Contraves Gun King sight which was first installed on the 35-mm GDF series of anti-aircraft gun. This features an optical sight with a magnification of ×5 and a 12° field of view, night sight, laser rangefinder with a range of 5000 m (5,468 yards) to an accuracy of ±5 m (5.46 yards), and a digital computer. Both the GBF-AOA and GBF-BOB have powered elevation and traverse to allow high-speed targets to be tracked: maximum traverse speed is 80° per second and maximum elevation speed is 48° per second.

The Diana can also be used in conjunction with the Contraves Sky Guard trailer-mounted fire-control system (originally designed for use with the Oerlikon GDF twin 35-mm cannon), which carries out both target surveillance and tracking. The Contraves Alerter radar can provide the gunner with the range and speed of the approaching target so the weapons are already laid in the general direction of the target as it appears.

As of early 1985 four prototypes of the Diana had been built with a turret suitable for installation on armoured vehicles.



The Oerlikon-Bührle Diana twin 25-mm light anti-aircraft gun has been introduced by the company to bridge the gap between its 20-mm and 35-mm weapons. Diana can be quickly brought into action and has rapid elevation and traverse, thanks to its on-board auxiliary power unit.

Specification
Diana
Calibre: 25 mm (0.98 in)
Weights: without ammunition 1725 kg (3,803 lb); with ammunition 2100 kg (4,630 lb)
Dimensions: length travelling 4.295 m (14 ft 1.1 in); width travelling 2.10 m (6 ft 10.7 in); height travelling 2.13 m (6 ft 11.9 in)
Elevation: +85°/−5°
Traverse: 360°
Ranges: maximum horizontal 6000 m (6,562 yards); effective horizontal 3000 m (3,281 yards); maximum vertical 5000 m (16,404 ft); effective vertical 2500 m (8,202 ft)
Crew: 4-5 (1 on mount)

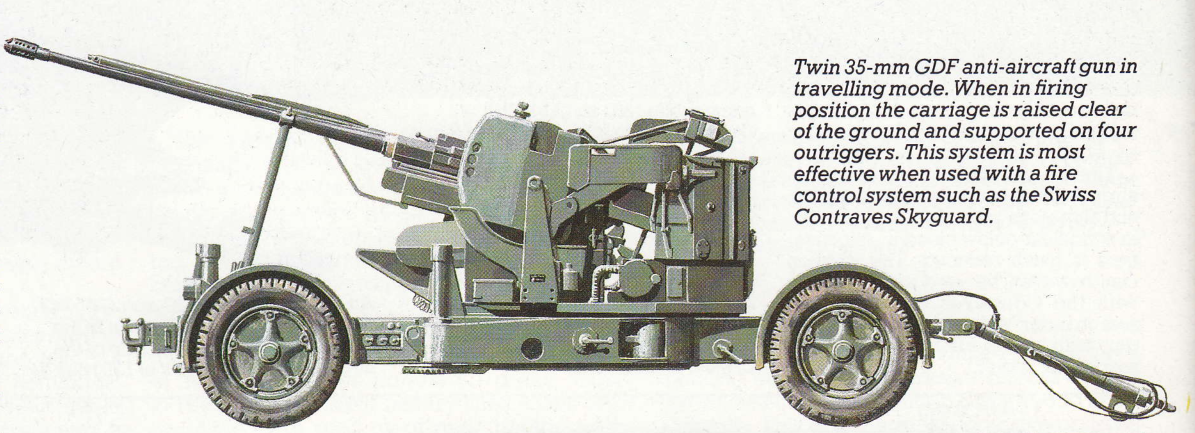
SWITZERLAND

Oerlikon 35-mm GDF anti-aircraft gun

In the late 1950s the Swiss company Oerlikon-Bührle developed a twin 35-mm towed anti-aircraft gun called the **1ZLA/353**, which today is more commonly known as the **GDF** series. Since this entered production in the early 1960s over 1,600 weapons have been built for sale to at least 20 countries. Known operators of the GDF series include Argentina, Austria, Brazil, Cameroun, Finland, Greece, Japan, South Africa, Spain and Switzerland. Early in 1985 it was announced that the British Royal Air Force Regiment was to form a new air-defence squadron equipped with the GDF twin 35-mm system to protect the Nimrod AEW base at Waddington, Lincolnshire. These GDF anti-aircraft guns were captured during 1982 in the Falklands, where they had been used by Argentina to defend Port Stanley airfield in conjunction with Rheinmetall twin 20-mm light anti-aircraft guns and Euromissile Roland surface-to-air missiles. It is believed that the Argentine GDFs shot down four British Aerospace Harrier aircraft and at least two Argentine aircraft as well.

The GDF twin 35-mm anti-aircraft gun system is mounted on a four-wheeled carriage. In the firing position the wheels are raised clear of the ground and supported on four jacks, one at each end and one on each side on outriggers. Weapon elevation and traverse are electro-hydraulic, traverse speed being a maximum of 112° per second and elevation a maximum of 56° per second.

Since its introduction the GDF has been constantly modernized and many of these modifications are now available in kit form to enable purchasers of older weapons to bring them up to the latest production standard. For example the basic weapon is fitted with a Ferranti sight but this can be replaced by the new Contraves Gun King mini-sight which also includes a laser rangefinder.



Twin 35-mm GDF anti-aircraft gun in travelling mode. When in firing position the carriage is raised clear of the ground and supported on four outriggers. This system is most effective when used with a fire control system such as the Swiss Contraves Skyguard.

The GDF series is armed with twin 35-mm KDB automatic cannon which have a cyclic rate of fire of 550 rounds per barrel per minute. The barrels are each fitted with a muzzle brake, and can be fitted with muzzle velocity-measuring equipment which feeds information to the fire-control system. A total of 112 rounds of ready-use ammunition is carried, with a further 126 rounds held in reserve on the mount. Each barrel has 56 rounds of ready-use ammunition in clips of seven rounds. Ammunition fired is of the fixed type and includes high explosive incendiary-tracer (HEI-T), high explosive incendiary (HEI), semi-armour-piercing high explosive incendiary-tracer (SAPHEI-T) and practice rounds.

The basic GDF is a clear-weather system only, but most countries prefer to use it in conjunction with a fire-control system. This was originally the Contraves Super Fledermaus, but this has been replaced in production by the much more effective Contraves Skyguard system. A typical GDF battery consists of two GDF twin 35-mm anti-aircraft guns, two generators and a single Skyguard fire-control system.

Although designed primarily for use in the anti-aircraft role, the Oerlikon-Bührle twin 35-mm GDF anti-aircraft gun system is also highly effective in the ground role, and was thus used by the Argentine army against the British in the 1982 Falklands conflict.

Specification
GDF
Calibre: 35 mm (1.38 in)
Weights: travelling (with ammunition) 6700 kg (14,771 lb); travelling (without ammunition) 6300 kg (13,889 lb)
Dimensions: length travelling 7.80 m (25 ft 7.1 in); width travelling 2.26 m (7 ft 5 in); height travelling 2.60 m (8 ft 6.4 in)
Elevation: +92°/−5°
Traverse: 360°
Ranges: maximum horizontal 9500 m (10,389 yards); maximum vertical 6000 m (19,685 ft); effective vertical 4000 m (13,123 ft)
Crew: 3 (on mount)

The Bofors

The reputation of the Swedish company Bofors was established over 50 years ago with the 40-mm L/60, which was widely used in World War II; today over 30 countries use its successor, the 40-mm L/70. Still only a clear weather system, albeit a very sophisticated one, it has now been developed into the all-weather BOFI system, incorporating multi-sensor fire control and high performance tracking systems.

The Bofors 40-mm L/70 is one of the most widely used anti-aircraft guns in the world today. Constant development, especially in ammunition and fire control systems, has enabled it to remain highly effective even though its basic design is now about 40 years old.

There is little doubt that the Bofors 40-mm anti-aircraft gun is the most famous weapon of its type in the world, and it has been and is used by the armies and navies of many countries. The US Air Force has even installed a 40-mm Bofors gun in one of its special Lockheed C-130 gunship aircraft to engage ground targets.

The current production model of the Bofors 40-mm L/70 towed anti-aircraft gun is essentially a clear-weather system. But today's field armies face attack from aircraft and helicopters that can fly in almost any weather, and from a variety of tactical missile systems. The Bofors 40-mm L/70 weapon can be made much more effective by the addition of a fire-control system, of which there are a number on the market. Many of these can be used with the Bofors and other anti-aircraft guns, and include the older Contraves Super Fledermaus and more recent Skyguard, and the Hollandse Signaalapparaten Flycatcher.

Bofors has developed its own fire-control system for the Bofors L/70 called the BOFI (Bofors Optronic Fire-Control Instrument), which in its basic form is a clear-weather system. It consists essentially of the Bofors L/70 Type B towed gun, a carriage-mounted electrical generator, the new proximity-fused ammunition, and the BOFI optronic system. The last consists of a combined day and night sight, a laser rangefinder and a computer. The gunner (seated on the left side of the carriage) tracks the target with the optical sight while the laser rangefinder feeds target information into the computer. The latter calculates the aim-off position required to hit the target. When the gun is firing the computer continues to predict the aim-off position by means of dead reckoning. The laser rangefinder and joystick are then switched off to prevent errors by the operator when the weapon is being fired. The day sight has a magnification of ×7 while the night sight has a magnification of ×8. The latter enables targets to be observed at a maximum range of about 7 km (4.35 miles) under good conditions. The optical target indicator is another useful aid with the BOFI system. This is positioned near the gun and when the operator sees a target he quickly lines up the pistol type arm with the target and then pulls the trigger, whereupon aiming information from the synchros of the target indicator are transmitted directly to the gun by means of a cable. Meanwhile a lamp lights up on the gun fire-control system and a buzzer sounds. The operator then presses a button for target indication and the gun automatically slews onto the target in both elevation and traverse. The gun crew then tracks the target as normal. The optical target indicator is of particular use in picking up targets that appear suddenly. The British Aerospace Dynamics Rapier towed system can also use a similar device, which has been found to improve the kill probability of the system by a considerable degree.

All-weather BOFI system

The all-weather BOFI system is the most sophisticated version of the Bofors L/70 series, and gives the system not only an all-weather capability against aircraft, helicopters and missiles, but also multi-sensor fire control and two high-performance tracking systems.

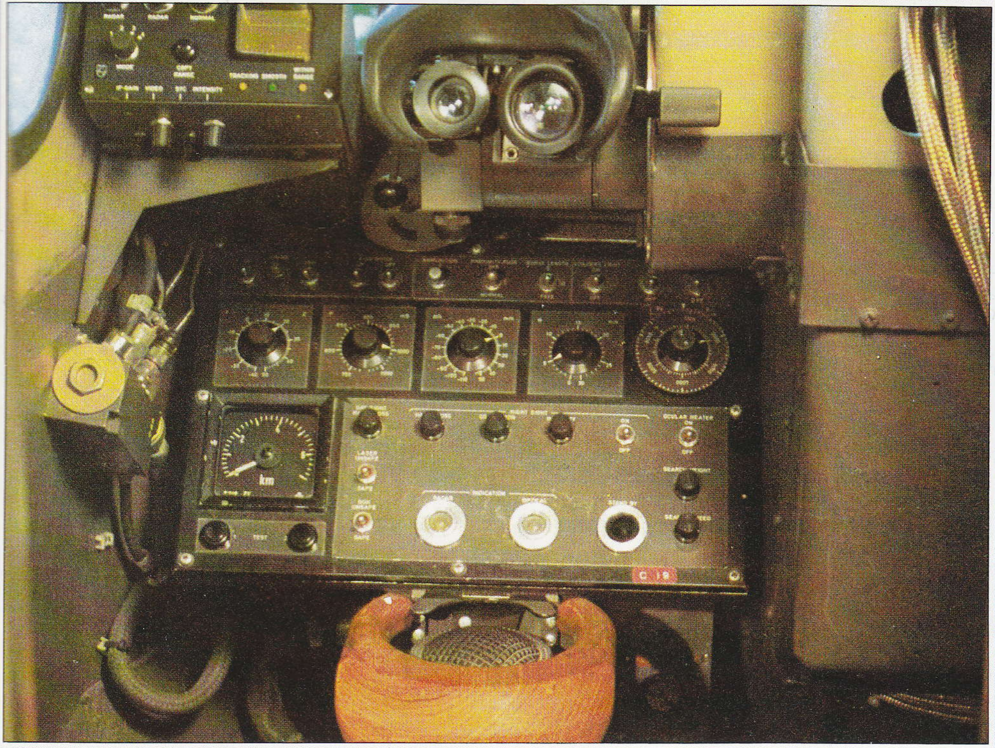
The BOFI tracking radar comprises three main units: the radar transceiver, the display unit with indicator and radar controls, and the power supply unit. Mounted over the elevating mass is the radar transceiver unit which is aligned with the axis of the optronic sensors; the display unit is mounted in the operator's cabin on the left side of the mount; and the power supply unit is located on the right side of the mount. The frequency-agile radar transceiver has two modes of operation, frequency agility and fixed frequency with MTI (moving target indication).

The tracking radar fulfils the following functions: designation and acquisition based on data from the fire-control system, radar tracking of targets and transfer of angle errors, and range of the target to the fire-control system.

Target acquisition is started by pushing the target indication button on the operator's panel whereby the position of the target is designated to the tracking radar. The radar acquisition area is centred around the designated position and the operator can correct the area at any time during the acquisition phase.

When a target is detected the radar automatically switches over to the tracking mode and a lamp indicating smooth tracking comes on. During tracking the computer of the BOFI fire-control system computes the angular rates in elevation and traverse, based on received range and angular tracking errors from the target. The operator can supervise tracking on the radar scope and when tracking is interrupted by enemy jamming, or when the target is masked by ground clutter, memory tracking (based on the latest target speed data) is carried out. At any time the operator can switch over to the normal optronic mode for manual tracking under fair-weather conditions. He can also at any time interrupt the tracking for a new acquisition by punching the appropriate button.

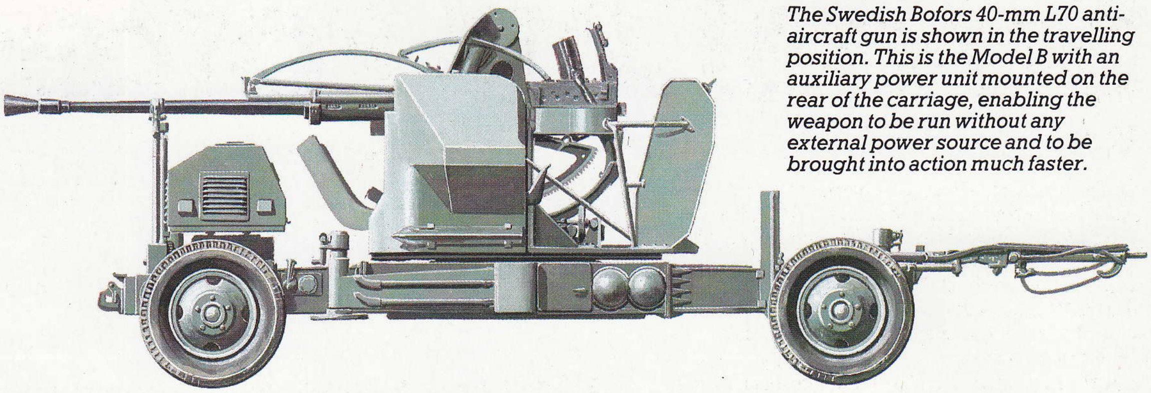
Late in 1984 the manufacturer announced yet another version of the Bofors L/70 system called Trinity. This is a modular system that includes the gun, ammunition and associated fire-control system, and can be used for both ship- and land-based applications. In the latter role it would be mounted on tracked or wheeled (e.g. 8×8) chassis for greater mobility than the current towed system. The Bofors L/70 gun and its ammunition is also used in the new American DIVAD self-propelled anti-aircraft gun system.



This is the gunner's position on the left side of the carriage. The basic 40-mm L/70 Bofors gun is a clear weather system, but a number of companies, including Bofors itself, now offer various fire control systems to give the weapon an all-weather capability which is now essential.

SWEDEN

40-mm Bofors L/70 anti-aircraft gun



The Swedish Bofors 40-mm L70 anti-aircraft gun is shown in the travelling position. This is the Model B with an auxiliary power unit mounted on the rear of the carriage, enabling the weapon to be run without any external power source and to be brought into action much faster.

Over 50 years ago the Bofors company developed a 40-mm towed anti-aircraft gun which within a few years became world famous. This had a 60-calibre barrel (resulting in the standard appellation Bofors 40 mm L/60) and had a cyclic rate of fire of 120 rounds per minute. This weapon was widely used during World War II and was manufactured under licence in many countries including the USA (as the M1), the UK (the Mk 1), Hungary, Italy and Poland. Even in 1985 the weapon remains in front-line service with more than 10 countries.

After the end of World War II a much-improved 40-mm light anti-aircraft gun was developed by Bofors, and this entered service in 1951 as the 40-mm **Bofors L/70**. In addition to having a longer 70-calibre barrel, the new weapon had a rate of fire increased to 300 rounds per minute (cyclic). This higher fire rate was achieved by ramming the new round during run-out and ejecting the empty cartridge cases forward of the mount towards the end of recoil. Initially two models of the Bofors 40-mm L/70 were offered, these being designated the **Bofors L/70 Model A** and **Bofors L/70 Model B**. The Model A relied on an external source for power while the Model B had its own generator mounted towards the front of the carriage.

The basic Bofors L/70 has a six-man crew, of whom four are on the carriage at all times: the elevation and traverse layers are seated one on each side of the mount, while two ammunition feeders are placed one on each side at the rear. Ammunition is fed to the weapon in clips of four rounds and an ammunition tray above the weapon can hold 26 rounds of ready-use ammunition. At the rear of the mount, one on each side, are ready-use racks that hold 96 rounds of ammunition.

Weapon elevation and mount traverse are electro-hydraulic, with manual controls for emergency use. Maximum elevation speed is 45° per second and maximum traverse speed is 85° per second.

Ammunition development is a continuous process at Bofors, and today five basic rounds are available for the Bofors L/70 anti-aircraft gun in its land and numerous naval applications. All ammunition fired by the gun is of the fixed type. The five types are pre-fragmented high explosive (PFHE), high-capacity high explosive (HCHE), high explosive-tracer (HE-T), armour-piercing capped-tracer (APC-T), and training. Additional details of the Bofors L/70 ammunition and its associated fire-control systems are given elsewhere.

In the firing position the wheels are raised clear of the ground and the carriage is supported on four jacks, one at each end of the carriage and one on each side on outriggers.

The Bofors L/70 has been made under licence in a number of countries including the UK, Italy, Spain, India, West Germany and the Netherlands. It is normally towed by a 4×4 or 6×6 truck, which also carries the crew and supply of ready-use ammunition. In some countries, for example the UK and West Germany, the Bofors L/70 has now been replaced by missiles such as Rapier or Roland. Nevertheless, with an up-to-date fire-control system, the Bofors L/70 remains a highly effective weapon system.

Specification

Bofors L/70

Calibre: 40 mm (1.57 in)

Weights: travelling (with generator) 5150 kg (11,354 lb); travelling (without generator) 4800 kg (10,582 lb)

Dimensions: length travelling 7.29 m (23 ft 11 in); width travelling 2.25 m (7 ft 4.6 in); height travelling 2.349 m (7 ft 8.5 in)

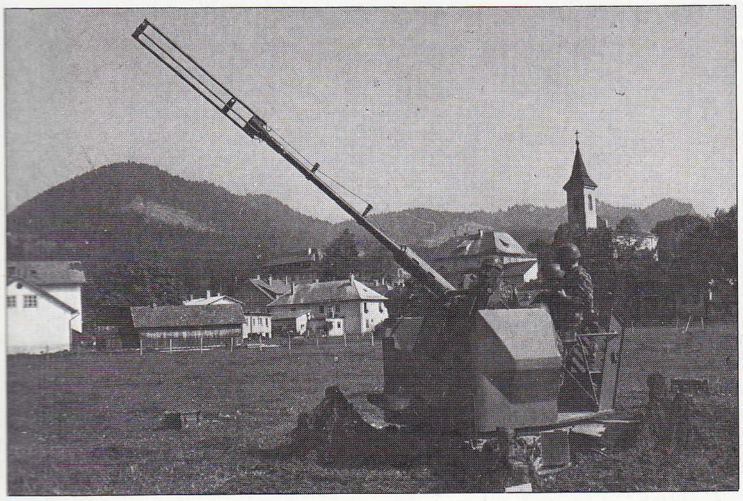
Elevation: +90°/–4°

Traverse: 360°

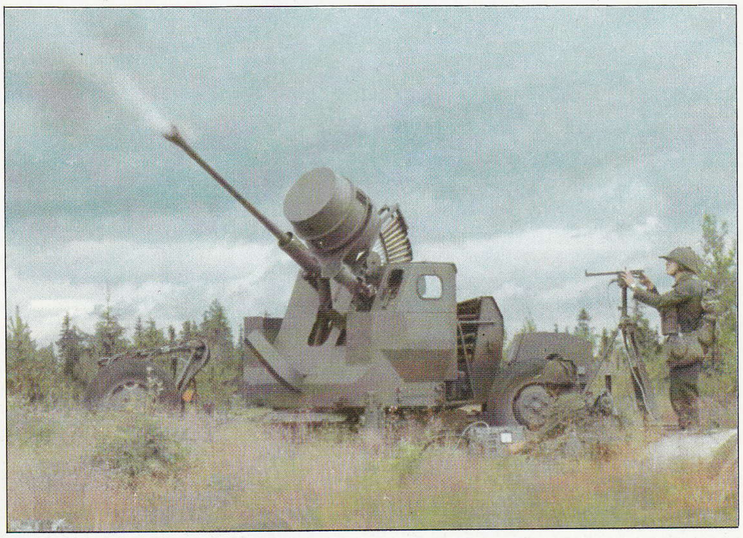
Ranges: maximum horizontal 12500 m (13,670 yards); maximum vertical 8700 m (28,543 ft); effective vertical 4000 m (13,123 ft)

Crew: 6 (4 on mount)

The Bofors gun has been primarily designed to engage aerial targets but can also be used with deadly effect against ground targets, including armoured personnel carriers with their thin armour. When engaging the latter an armour-piercing capped-tracer (APC-T) round is normally used.



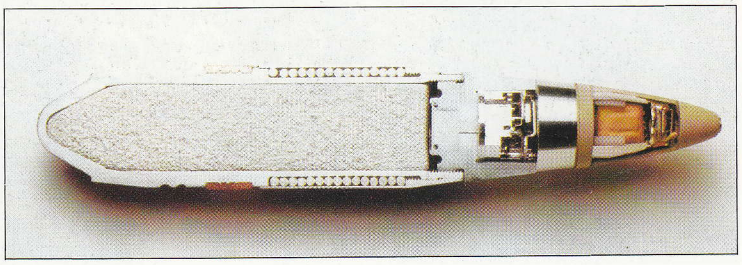
Right: The 40-mm L70 Bofors gun has a cyclic rate of fire of 300 rounds per minute, but practical rate of fire is lower. The ammunition is fed to the gun in clips of four rounds, with the empty cartridge cases being ejected under the forward part of the mount. A maximum of 26 rounds of ammunition are for ready use.



Below left: Projectile for the Bofors 40-mm PFHE (pre-fragmented high-explosive) round fired by the 40-mm L70 gun, which has a proximity fuse for greater effect.

40mm L/70
PFHE MARK2

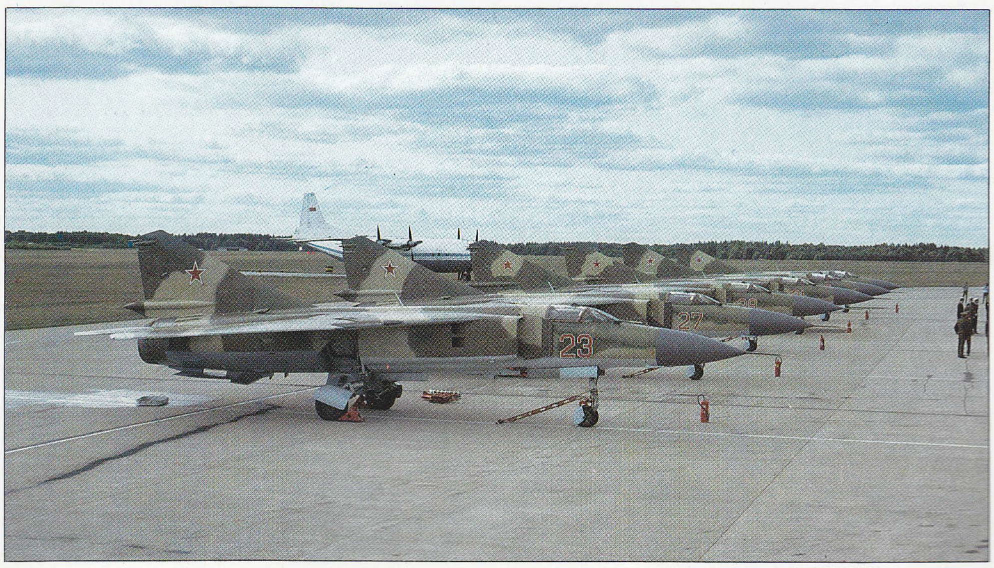
Below: Cross-section of the new Bofors 40-mm PFHE (pre-fragmented high-explosive) round, with the fuse on the right and high-explosive content on left.



Armed Forces of the World

Soviet Air Forces

Part 2



The West has had many chances to inspect the Mikoyan-Gurevich MiG-23MF 'Flogger-G' during its trips to Finland and France. These six are backed up by an Antonov An-12 in quasi-civil colours (despite the tail gun turret). MiG-23s are rapidly replacing the MiG-21 in Soviet units.

The Soviet aviation component most closely matching a Western air force is the Voyenno-Vozdushnyye Sily (V-VS), in which are included Long-Range Aviation (the strategic bomber arm), Transport Aviation and Frontal Aviation (FR). Of these three, the roles of the first two are self-explanatory, but the FA (Frontovaya Aviatsiya) is a specially balanced force worthy of detailed study.

Whereas some of the world's principal air forces have fought hard to distance themselves from the army from which they sprang, the V-VS has remained closely allied with ground elements of the armed forces. Nowhere is that harmony better illustrated than in the FA, which is attuned to the support requirements of the Red Army in battle.

FA units are assigned to the five Air Armies allocated to Theatres of Military Operations together with air-defence (Voyska PVO), transport and bomber squadrons. Until 1981, 16 Frontal Air Armies (FAAs) constituted FA and were assigned to the Leningrad, Baltic, Belorussian, Moscow, Carpathian, Odessa, Kiev, Transcaucasian, Central Asian, Siberian, Transbaikal and Far East Military Districts, plus the Soviet forces in East Germany, Poland, Czechoslovakia and Hungary. (The North Caucasus, Turkestan, Ural and Volga Military Districts had no Frontal Air Armies.)

In the recent regrouping of air forces to facilitate more rapid war mobilization, the FAAs have been replaced by Air Forces of Military Districts (AFMDs). An AFMD now combines all aviation units in its area except bomber and transport elements, but is generally similar in function to the disbanded FAA. In wartime, between three and five AFMDs would be attached to one of the 13 Theatres of Military Operations, such as the Western TMO, which faces NATO in Central Europe. Air Forces comprise Divisions (Diviziya) with subsidiary Regiments (Polka) of three Squadrons (Eskadriliya) of 15 aircraft each, the last-mentioned including two or three operational trainers.

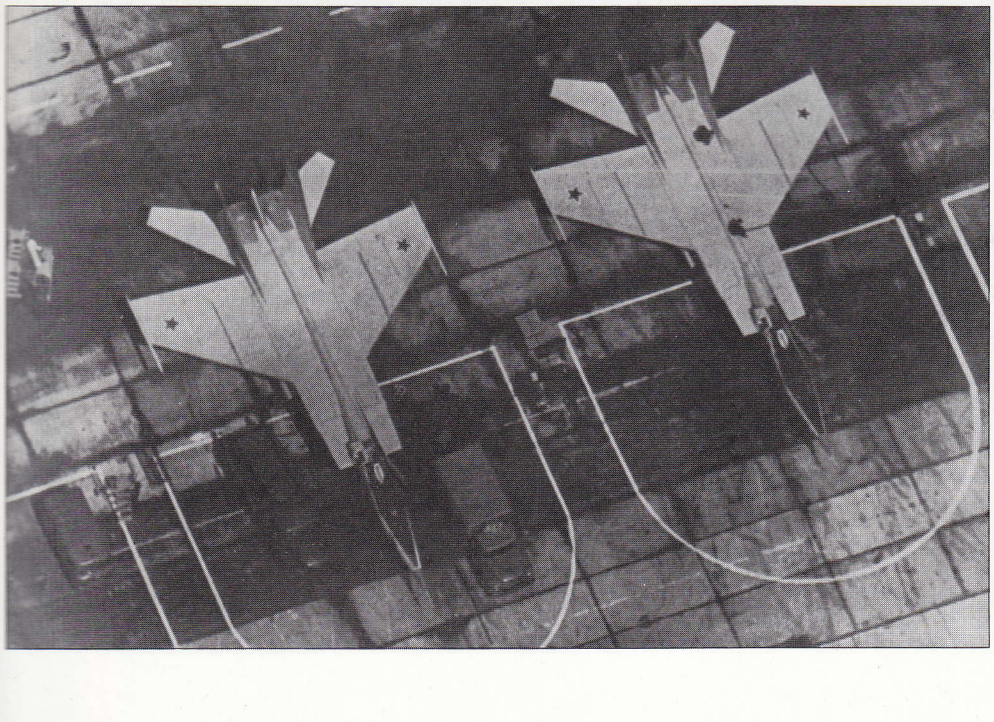
Until the advent of recent, multi-role aircraft, divisions were assigned a specific task, but now they can switch rapidly from role to role according to the tactical situation. Three main functions may be identified: air defence (meaning over the battlefield, and leaving other units to protect the homeland); air preparation (known as interdiction in the West); and air support (attacks on the battlefield). In addition, squadrons can be detailed to undertake tactical reconnaissance and provide electronic countermeasures with appropriate aircraft.

In the past dozen years, the FA has changed dramatically from a purely tactical force to one with the potential for offensive operations beyond the immediate bounds of the battlefield. In total, it comprises some 6,000 aircraft disposed according to the strategic situation. Thus, in the area bordering European NATO members, three Theatres of Military Operations include the major share of air assets, led by the Western TMO (NATO's central front) with 2,850 aircraft, over 90 per cent of them modern types.

The more sparsely-defended South-Western TMO demands 1,250 aircraft, but relatively few are allocated to the frozen wastes of the North-Western TMO. The Southern area has 850 tactical aircraft, whilst the Far East TMO (last of the five continental Theatres) operates an up-to-date force of 1,800 aircraft. The potential adversary here is Japan, although relations with the fellow Communists in China have been turbulent enough for war contingency plans to have been made.

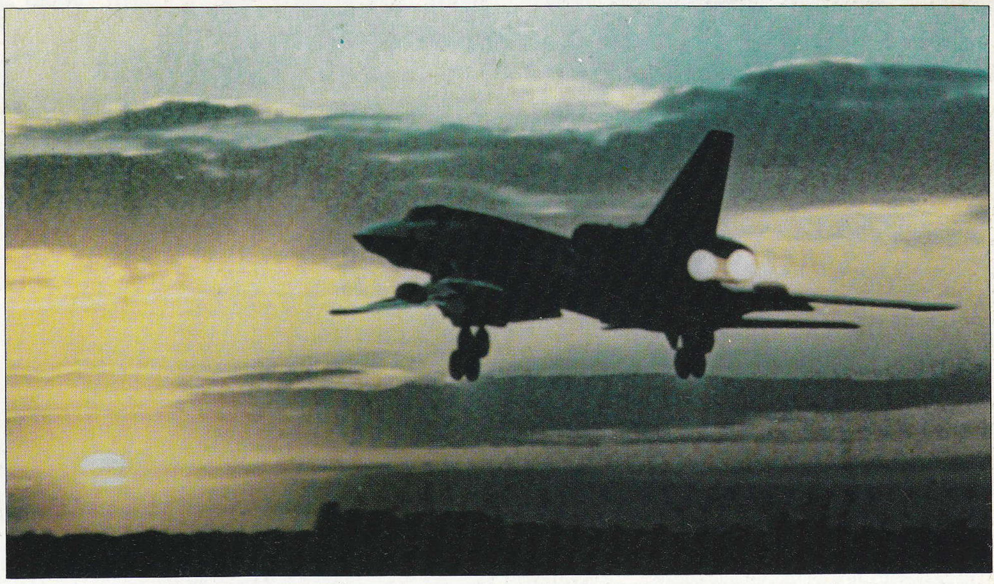
In the past decade, the FA has expanded its radius of action following introduction (from December 1974) of the potent Sukhoi Su-24 'Fencer'. Over 400 are in service with regiments based at Tukums (Latvia), at Chernyakhovsk (Soviet Baltic), at Starokonstantinov and Gorodok (Ukraine), at Templin (East Germany, from 1979) and in the Far East. The 'Fencer', aided by variable-geometry wings, has a hi-lo-hi combat radius of 1800 km (1,120 miles) when carrying 2000 kg (4,409 lb) of weapons, and in the lo-lo-hi mode can reach the airfields of East Anglia, plus those of north west France and most of Italy, from its home bases.

The impact of the 'Fencer' has been profound, for it is the first modern Soviet fighter designed for ground attack and the first to carry a weapons systems officer (in a side-by-side seat cockpit similar to that of its nearest NATO equivalent, the general Dynamics F-111). In addition to navigation and attack radar, it has a terrain-avoidance system, and a laser ranger and marked-target seeker, and can deliver ordnance with an accuracy of 55 m (180 ft) in all weathers. When used for short-range operations, it



Soviet reconnaissance assets rest on specially equipped MiG-21s and 23s, and in the MiG-25R. These are two MiG-25R 'Foxbat-Ds' which carry a large SLAR (side-looking airborne radar) in the left side of the nose. Under the NATO codename of 'Ram-M', the Soviets are believed to be building a TR-1 type high-altitude spyplane.

12 PASS



Now an ageing design, the Tupolev Tu-22 'Blinder' is still in limited service both as a reconnaissance bomber and on maritime reconnaissance duties. It is thought that 'Blinders' have been used for level-bombing attacks on guerrilla strongholds in Afghanistan, and Libya has used her aircraft in anger over Chad.

may carry a formidable load of up to 8000 kg (17,637 lb).

Having learned lessons from the various small-scale wars of the past 20 years (such as those in the Middle East), the FA is placing emphasis on the attainment of local air superiority in order that strike and attack aircraft may go about their business unhindered. In this area, some 900 MiG-23 'Flogger B/Gs' are supported in part by an equal (but diminishing) number of late-generation MiG-21 'Fishbed J/K/L/Ns', which are also employed in air support. The 'Floggers', similar to those in the Voyska PVO use, have internal cannon and AA-7 and AA-8 air-to-air missiles.

Less visible than this armoury, but of no lesser importance, is the training given to air-superiority pilots in the FA. The past five years have witnessed an increase in experimentation with new tactics and the development of training for several missions new to the Soviet forces: fighter escorts, ECM (electronic countermeasures) escort, manoeuvring air combat, independent search missions and air accompaniment of ground forces. More emphasis has been placed on dissimilar air combat training (possibly even with 'aggressor' squadrons) and multi-event training sorties. Such will encourage flexibility of tactics to exploit a changing battle situation and the more efficient use of multi-role aircraft.

For air support and secondary interdiction, the Sukhoi Su-17 'Fitter' and MiG-27 'Flogger' are employed, about 800 and 650 respectively serving in the FA. Typical of the Soviet penchant for adaptation, the MiG-27 is a simplified MiG-23 which trades speed for simplicity and increased payload. Its lo-lo-lo radius of action with a typical load of four 500-kg (1,102-lb) bombs and two self-defence AA-2 AAMs is 385 km (240 miles).

A further illustration of Soviet trends is found in the Su-17, which is a variable-geometry adaptation of the earlier Su-7. A few Su-7 'Fitter-As' may serve in low-threat areas, but the type's indifferent load-carrying capability has been greatly improved in the Su-17 'Fitter-C' and derivatives. Like its MiG-27 companion, it lacks all-weather penetrative avionics, but its lo-lo-lo range of 360 km (225 miles) is a useful asset.

Reconnaissance is provided by MiG-21 'Fishbed-Hs' and MiG-25 'Foxbat-B/Ds', perhaps assisted by a few remaining Yakovlev Yak-28 'Brewer-Ds'. Dedicated ECM and Elint (electronic intelligence-gathering) is performed by a handful of 'Brewer-Es' and Antonov An-12 'Cub-Cs', although large numbers of combat aircraft are detailed to operate in the electronic jamming role.

In at least one (and possibly another) new area, the FA is receiving aircraft which parallel those recently added to the NATO armoury for tactical warfare in a European environment. A parallel to Fairchild's A-10 Thunderbolt II is to be found in the Sukhoi Su-25 'Frogfoot', in that both are rugged close-support jet aircraft. The Soviet aircraft has no less than 10 underwing stores attachment points, together with a heavy-calibre, Gatling-type cannon in the belly, and an operational radius of some 480 km (300 miles) whilst carrying 4535 (10,000 lb) of stores.

The 'Frogfoot' entered limited operational service in Afghanistan during 1982, where it is used for attacks against guerrilla strongholds, and now equips FA regiments in Bulgaria and elsewhere. One of its associated missions during the Afghan deployment has been to evaluate methods of close liaison with armed helicopters, something already practised by the USAF Thunderbolt.

The second new FA aircraft could be an equivalent to the Lockheed TR-1, presently only identified by the provisional NATO code name 'Ram-M'. This aircraft would undertake stand-off radar and infra-red surveillance of the battlefield and relay its findings to ground commanders for rapid exploitation.

Even before helicopters are considered, the assets of the Frontovaya Aviatsiya indicate that it is a well-equipped force optimized for conventional and limited nuclear warfare. By dint of hard work and careful acquisition of Western technology (using overt and covert means), the Soviet Union has brought its tactical forces close to the level of their Western counterparts and instituted training which will eventually permit the full potential of versatile new equipment to be realized.

Bearing a similarity to the MiG-27 on account of its downward-tapering nose (for ground attack duties), the MiG-23BN 'Flogger-H' still bears the variable-geometry intakes of the air defence versions. This version has been supplied to the air forces of Bulgaria, Czechoslovakia, Poland and India.